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SOME PHYSICAL PROBLEMS IN THE FIELD OF MEDICINE[1]

IT is not so very many years ago that the well-educated physician, as a gentleman of broad culture, was expected to possess an easy familiarity with the entire field of natural science as well as a training in the disciplines of the ancient classics and the gems of modern literature. I need only remind you that one of the leading physicists of the preceding generation, Hermann von Helmholtz, was at the beginning of his career a physician. The famous essay on the "Erhaltung der Kraft" was published in 1847 while he was still on active duty in the German army as a military surgeon. After a brilliant career as a professor of physiology, he finally became professor of physics at the University of Berlin. His activities in that capacity and the record of the brilliant pupils whose work he stimulated are well known to all of you. I mention this example to indicate the magnitude of the change which less than half a century has wrought in the subject of physics. It is no longer possible for the medical man to be a master in the fundamental sciences, physics and chemistry. The very existence of the Optical Society evidences the increasing content of a single branch of physics. Moreover, the fact that in the meetings of the Physical Society we now have groups of papers on related subjects presented before sections of the society, emphasizes the difficulty of keeping up with the progress of the science. When the professional physicist is obliged to admit that he experiences difficulty in understanding the content of papers which deal with matters outside the particular field of his personal research activity, it will be readily appreciated that never again may we expect to see a physician possessed of such breadth of culture in this branch of science as Helmholtz had unless it may become possible through some trenchant generalization which shall bring back comparative simplicity. As a matter of fact I do not visualize the future of natural science as a labyrinth of ever-increasing complexity. Each new generation starts off with the best of what its predecessors possessed and does not hesitate either from habit or sentiment to discard what seems less fit to serve its purpose. We who are older have accumulated a miscellaneous lot of

[1] Read before a joint meeting of the American Physical Society and the Optical Society of America, at Columbia University, New York, February 23, 1929.

intellectual furniture which seems to increase the difficulty of finding room for new pieces, especially when they are of an entirely different "period" and do not harmonize with our previous accumulations. However, the fact remains that the rapid growth of theoretical and experimental physics presents a real difficulty to the cultivators of other branches of science who know that their own work will rest on insecure foundations unless they are familiar with the fundamental facts and concepts of this subject and who suspect that their productiveness may suffer if they fail to maintain some sort of contact with its progress and present state of thought.

From the standpoint of chronological development, chemistry may be looked upon as a younger brother of physics. For a long time medical men regarded chemistry mainly as an aid to the preparation of substances to be used for remedial purposes. A few of those better informed realized the possibilities of applying chemical methods to the study of physiology and pathology, and the rank and file of the profession rather suddenly woke up to the fact that chemistry offers powerful tools for attacking certain biological problems. I think this appreciation of the fundamental importance of chemistry and the rapid development of laboratories of biological chemistry may have been responsible for a tendency which was well marked about thirty years ago for medical students to emphasize the study of chemistry and to neglect the study of physics. Not that they have ever failed to study physics, but their attitude toward it was lukewarm. It was required as a cultural discipline not definitely related to their later work as chemistry then seemed to be. As a result a whole generation of physicians came into the profession with a comparatively meager command of physics at just about the time when physics was beginning to undergo that striking metamorphosis which began in the nineties of the last century. Perhaps the fact that chemistry as generally taught at that time was an almost entirely non-mathematical science was not without its influence in determining a willingness on the part of medical students to emphasize this subject in their preparation. Do not think that I undervalue sound preparation in chemistry as a basis for the study of medicine. It is fundamental and indispensable. The generation of doctors which began to come into the profession in the nineties were merely the victims of circumstance. Even the chemistry which they thought they were mastering has now become so involved with physics and mathematics that they find themselves unable to follow its developments.

In 1895 Roentgen discovered the X-rays. The fact that they penetrate the soft parts of the living body readily, casting well-defined shadows of the bones, led medical men to seize upon them immediately as an aid to diagnosis. A little later, at great cost in health and life, the destructive effects of these rays were discovered and suggested their use as a means of destroying or delaying the development of inoperable malignant growths. Also within a short time of Roentgen's discovery came Becquerel's discovery of radioactivity with the well-remembered sequence of important discoveries which followed. Again medical men found the radiations from radium effective in the palliative treatment of inoperable new growths. More recently it has been learned that the ultra-violet radiation of sunlight as well as similar radiation from artificial sources exerts a beneficial influence on certain of the vital processes of the animal body. With the desire to employ a powerful new agency for the control or alleviation of disease comes also a sense of responsibility, a realization that any form of energy capable of exerting beneficial effects is probably capable of producing undesirable ones also. Indeed, examples of these undesirable results were not slow in appearing. The intensity and quality of radiation can be measured. The physicist gladly explains the methods, but how many times the medical man has found the explanation to be in a strange language.

For many years there has been a group of physicians who have employed, and advocated the employment of, various means such as radiant heat and light, mechanical manipulation, electrical stimulation and the passage of electrical currents through diseased parts as curative procedures in addition to or as substitutes for drug therapy. Some of these men in their enthusiasm made claims so extravagant as to lead their more cautious confrères to look askance on the whole subject of physical therapy. Those who believed that good results were sometimes obtained were half inclined to attribute them to psychological effects on the patient. During the war, however, the serious and conservative student of physical therapy had an opportunity to practice his methods in the attempt to hasten the rehabilitation of sick and wounded soldiers, and the results were so striking as to convince the profession as a whole that the employment of physical measures in the treatment of certain disabilities should no longer be neglected. This important branch of medicine is still in its infancy, but is now recognized. Several years ago the American Medical Association established a Council on Physical Therapy, one of the duties of which is to see to it that manufacturers of equipment designed to be applied in the practice of this branch of medicine shall not deceive the less well-informed members of the profession by advertising apparatus with false or extravagant claims.

In the city of Syracuse, N. Y., there is a physical therapy clinic for the rehabilitation of injured workmen. The saving which has been effected in the few years during which this clinic has been in operation when expressed in the money value of workmen's time saved runs into figures which are most impressive.

A word now as to the effect of the general lack of adequate fundamental knowledge of physics on the part of physicians. For years most of the physicians who employed X-rays have purchased their apparatus on the recommendations of the salesmen. They have often received their instruction from the makers of the apparatus and the instruction has been of the cook-book type. When anything went wrong the doctor sent for a service man to try to set it right. Skill of a certain kind came with experience, but knowledge of the underlying phenomena was lacking. At the present time the manufacturers of apparatus for physical therapy print literature and even employ men to give instruction to physicians in the use of their equipment. Sometimes the information is reasonably correct and claims not altogether extravagant. Sometimes it is otherwise. Sometimes the "physics" taught by these high-pressure salesmen is a strange mixture of technical words and nonsense. They are able in this manner to impress the average medical man because he is quite at their mercy and can not question their statements.

As regards the physician who graduated a score or more of years ago, there is little to be done. Some of these men, not content to be mere pullers of handles, have undertaken to read physics and some have succeeded in a considerable measure, but the majority must rest content to do their work with the equipment they happen to have acquired and there will always be plenty for these men to do.

Our interest in this matter lies largely with the physicians of the coming generation. There was a time when the older men, not realizing that their own meager knowledge of the fundamental sciences had proved in any way a handicap to them, advised prospective students of medicine not to waste time in extensive study of physics or mathematics. I think there is now less tendency to decry such preparation. When the speaker first came to Columbia some eighteen years ago, it was the exception to find a medical student who remembered anything of his physics with sufficient definiteness to make practical application of it. Gradually there has developed a tradition which has spread from the medical school to the premedical students that physics has its place in the foundations of the medical sciences and even in the practice of medicine. In recent years there has been an increasing number of students who have studied physics with interest and who retain such a grasp of the principles as to be able to make immediate application of them. I have also noted with interest the increasing number of medical students whose preparation in mathematics includes the calculus and the elements of differential equations. They find this preparation useful not alone in physics but also in chemistry, and from time to time they find further applications in physiology. I have recently received from Professor A. V. Hill, in London, a reprint of a physiological paper on the diffusion of oxygen and lactic acid through tissues which is largely mathematical. Among the equations in this paper I noticed the Fourier equation of the form,

$$\frac{d^2u}{dx^2}+\frac{1}{x}\frac{du}{dx}+u=0,$$

the general solution of which is,

$$u=AJ_0(x)+BK_0(x),$$

where $J_0(x)$ is the Bessel's Function of zeroth order of the first kind and $K_0(x)$ is the Bessel's Function of zeroth order of the second kind.

From this it will appear that the prospective student of medicine may carry his mathematical training rather farther than such students usually do and still find applications without going outside the field of medical sciences for them.

I doubt if it is necessary to require of the prospective medical student more hours of work in physics than are now required. The principal consideration seems to be the awakening of the student's interest. He must be made to realize that for him the study of physics is of as great practical importance as it is for the student who is preparing for the study of engineering. The better college courses in physics seem adequate to prepare the student to undertake more advanced reading by himself if and when he finds that his work requires it, provided that his interest at the time he takes the course is such that he gives it his best attention, realizing that he will one day require it just as certainly as the surgeon requires anatomical knowledge. Any student knows that a surgeon's knowledge of anatomy must be such that it can be used at once for practical purposes. It is not sufficient to have acquired a smattering, to have understood the subject in a general way. If he will take the same serious view of his physics he will retain its important concepts as foundation stones for future use. He will, or should, require it before he ever reaches the medical school as an aid to the study of chemistry.

It may be asked why physicians confronted with problems requiring knowledge of physics have not

more often consulted physicists. They have tried to do so. If any of you have ever tried to extract information in a foreign country from a native whose language you do not speak and who knows nothing of your own you will appreciate the position of the average doctor of the older generation who seeks aid from a professional physicist. He finds the greatest difficulty in stating his problem in language the physicist will comprehend and if he succeeds in doing this the assistance will come to him in terms which either mean little or nothing to him, or worse still in terms to which he attaches a meaning which is not the one the physicist intends. It has often been the speaker's lot to act as a sort of interpreter or go-between for physicians in this situation, since he has happened to know something of both languages. Twenty years ago he had not infrequently to explain to doctors why though it was perfectly proper to attach the ends of a power circuit to a voltmeter to determine the voltage of the circuit, it was not also in order to attach these same wires directly to an ammeter to determine whether the proper current would flow. All sorts of questions arise. In recent years the inquiries often pertain to sources of ultra-violet radiation, methods of measuring the intensity of such radiation, filters and the extent to which intensity is lost in limiting the range of wave-lengths, etc.

Really to get along with his problems the physician must be able to work on them and think about them himself. He may avail himself of advice and assistance, but he can hardly expect men who are busy with their own problems to turn aside long enough to solve all his when they enter the field of physics. Almost any good-natured physicist will listen to the statement of his problem and offer suggestions, but the medical man must know the language, he must have enough training to be able to read and go ahead with his own experiments.

In addition to the necessity for impressing upon the prospective student of medicine the importance of actually mastering the fundamentals of physics, there seems to be an urgent need for the inclusion in the staff of our medical colleges of at least one member whose training in physics has been as extensive as one would expect it to be in a young man who has just completed the work for a doctorate in philosophy in that subject. A young man with this training can, through association with men trained in present biological methods and familiar with the literature of the subject, readily become oriented in the new field and bring his own intellectual armamentarium to bear on its problems. He should not be expected to teach physics in the medical school. Rather he should be primarily an investigator. His teaching activities may properly include some supervision of the work of graduate students. It might well include some work with undergraduates in medicine on subjects which can not be included in their preparatory work in physics through lack at that time of the biological background. There are many such subjects. The effects of radiation on the various life processes would alone furnish material for several exercises. Such work could not be introduced without deleting something from an already topheavy curriculum, but I think this might well be done if a proper instructor were available to give the new material. It is the research aspect, however, which is the most important and pressing. There is an actual demand for qualified young men for a few positions of this kind at the present moment and I am certain this demand will grow. As instances that the selection of a man trained primarily in a fundamental science rather than in biology is not without precedent I may mention that Professor A. V. Hill, whose work I have already referred to, trained primarily as a mathematical physicist, has been most successful in physiology as is attested by the award to him a few years ago of the Nobel prize in physiology.

Columbia University has recently called to the chair of biochemistry in the medical faculty an organic chemist, Professor H. T. Clarke, who had no previous biological experience. This was done because it was regarded as of the first importance that the work of this department should be based on sound knowledge of the fundamental science. The same principle should guide in biophysics. It would be useless for a physicist to undertake work in the biological field without availing himself of the advice of biologists and of such sound biological information as is available in the literature. On the other hand much time and effort has been wasted by biologists who have tried to avail themselves of physical methods without a sound training in its theory and practice.

As an example of one of the physical problems which confronts the student of medicine I may cite the difficulty he has in learning anything about the physics of the conduction of electricity through gases, thermionic emission, the phenomena of X-ray tubes, the measurement of intensity and quality of X-rays, the measurement of high voltages, the principle on which the various kinds of electrical vacuum valve tubes operate, the construction and adjustment of apparatus for the production of a high tension pulsating direct current and various other subjects which are fundamental to sound knowledge of the application of Roentgen rays in medicine. These subjects are not treated in the elementary course which is open to premedical students. They are usually covered in

advanced courses, prerequisites for which are courses in mathematics which only a few premedical students elect.

To meet this need the speaker conducted for a number of years a course of lectures illustrated with experiments and presented in such a manner as to avoid the use of mathematics beyond algebra and trigonometry. These courses were well attended, and not infrequently in addition to the medical students, graduate physicians who were making use of X-rays in their practice requested permission to attend. It is conceivable that a professor of biophysics in a medical college might develop a much better course of this kind dealing with the biological effects of X-rays and perhaps including also the effects of other radiation and means for its production and measurement.

By far the most important need is for the close cooperation of the physicist, the chemist, the physiologist, pathologist and others in an attempt to evolve rational theories to coordinate and explain the immense amount of curious and interesting experimental data which workers in the various fields of biology have accumulated.

The medical sciences already owe a large debt to physics. They have had at various times the services of more than one eminent investigator in that field. There remains a wealth of problems still unsolved and with the powerful aids which recent advances in physics make available it should be possible to secure results with greater ease than ever before. May I leave with you first of all the suggestion that students about to enter upon their premedical work should be impressed with the importance of making the utmost use of the opportunity which is afforded them in their course in college physics. In addition may I suggest that occasionally an advanced student of physics who has developed an interest in its biological applications may find in biophysics a field of activity where there is an abundance of interesting problems to tax his ingenuity and where he may, if fortunate and industrious, achieve results whose importance can hardly be estimated.

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THE MECHANISM OF SPARK DISCHARGE IN AIR AT ATMOSPHERIC PRESSURE

SOME fifteen years ago the mechanism of the electric spark in air was considered as quite satisfactorily described by the classical theory of Townsend.[1] In recent years this theory has been seriously called into question by the researches of Holst and Oosterhuis,[2] and James Taylor.[3] As shown by the writer in a recent article[4] the serious difficulty with the original theory of Townsend lay in the fact that the mechanism of spark discharge proposed assumes ionization by the positive ions of the gas through collision with gas molecules in such a manner and measure as to produce enough electrons in the neighborhood of the cathode as to make the discharge self-maintaining. This means that the positive ions must gain enough energy in moving through several free paths in the field to enable them to ionize neutral gas molecules by impact. Now in recent years the ability of the positive ions to ionize molecules by impact has been seriously questioned.[5] Furthermore Taylor and Holst and Oosterhuis believed to have shown in inert gases at low pressures that the nature of the cathode surface plays an important rôle in the mechanism of the spark as the alkali metals like Na and K gave distinctly lower sparking potentials under these conditions than more inert metals. The possibility that at low pressures in spark discharge the generation of electrons from the electrode surface occurs through positive ion impact (an effect characteristic of the metal as their results indicate) was also scouted by these authors as unlikely for two reasons. The first one was that electron emission by positive ion bombardment on an outgassed surface is a phenomenon requiring high potentials as shown recently by Jackson.[6] The second reason is that in the fields assumed the positive ions could only extremely rarely (one in 10^{-17}) acquire the ionizing energy over a mean free path in the gas.

Now the writer[4] pointed out that metal surfaces even in inert gases were not "outgassed" so that positive ions of 20 or less volts equivalent energy could remove electrons.[7] He further stated that the assumptions as to the values of the fields occurring near the cathode just at sparking (which gave the low values for the energy of impact of positive ions) were both gratuitous and probably contrary to fact. In his original deductions Townsend assumed that the fields were uniform and that the sparking potential gradient was merely the sparking potential divided by the distance. This assumption was probably made for simplicity only, and Townsend[1] himself provided the possibility of non-uniform fields at breakdown in

[1] J. S. Townsend, "Electricity in Gases," Clarendon Press, Oxford, 1915. pp. 322, 330 and 429.

[2] *Phil. Mag.*, 46: 1117, 1923.

[3] *Phil. Mag.*, 3: 753, 1927; *Proc. Roy. Soc.*, 114A: 73, 1927.

[4] *Jour. Franklin Inst.*, 205: 305, 1928.

[5] L. B. Loeb, SCIENCE, 1928.

[6] W. I. Jackson, *Phys. Rev.*, 28: 524, 1926; 30: 473, 1927.

[7] H. Baerwald, *Ann. der Physik*, 41: 643, 1913.

his theoretical treatment. In the study of the values of the ionization functions $\frac{\alpha}{p}$ and $\frac{\beta}{p}$ for the electrons and positive ions in a gas, Townsend actually worked under conditions where the fields were sensibly uniform, but where the ratio $\frac{X}{p}$ (field strength in volts/cm divided by pressure in mm of mercury which was the important variable in the process) was very high (of the order of 100 to 1,000 as compared to the value of 39, $\frac{30,000}{760}$ for $\frac{X}{p}$ for sparking at atmospheric pressure assuming uniform fields). The ionization functions obtained by Townsend at these high values of $\frac{X}{p}$ satisfied the conditions for sparking but not under ordinary conditions of spark discharge in air at atmospheric pressure.

In his previous article the writer showed that it was only necessary to assume that before the spark discharge passed, through the medium of the dark current preceding breakdown, non-uniform fields of the order of magnitude of those investigated by Townsend should build up as a result of space charge effects. Such fields at atmospheric pressure would have to be fields of from 1×10^5 to 10^6 volts/cm. It was shown that such fields could be expected as a result of space charges due to the fact that electrons travel with velocities of 2,000 cm/sec in unit field compared to about 2 cm/sec for positive ions. The theory, however, required that time intervals of the order of 10^{-4} seconds should be involved in the building up of the space charges owing to the low velocity of the positive ions. The writer therefore stated that such time intervals must constitute the "time lag" of the spark under uniform conditions.

Since the writing of the above cited paper[4] many new developments have taken place. L. J. Neumann[8] in the writer's laboratory showed by experiment that it was probable that in argon and the inert gases the mechanism of breakdown did not consist of the mechanisms postulated by Holst and Oosterhuis and Taylor (action of electrical image forces and photoelectric effects on the metal); but that they consisted as had earlier been postulated by J. S. Townsend and J. J. Thomson[9] of the liberation of electrons from the cathode by positive ion bombardment. At higher pressures in argon (20 mm pressure), the phenomenon in Neumann's experiments went over to a phenomenon which was independent of the nature of the electrodes, indicating definitely that at higher pressures the ionization by positive ions was taking place in the gas itself as initially suggested by Townsend. This conclusion is in agreement with the fact that it is only by such a mechanism that the discharge from positively charged points in gases at higher pressures can be explained.[10] In the interim also the beautiful experiments of R. M. Sutton,[11] at California Institute of Technology, have beyond doubt proven the rather copious ionization of the gases O_2, N_2, Ne and Ar by positive ions of Na and K above 100 volts energy. The most significant discovery of all, however, was a discovery made independently and with different methods by Pedersen,[12] Rogowski,[13] Torok[14] and Beams[15] that for nearly plane parallel electrodes at potentials exceeding the normal breakdown potential by from 50 per cent. to several hundred per cent. the time lag of the spark was surprisingly short, *i.e.*, from 10^{-7} to 10^{-8} seconds. This value of 10^{-} seconds is so far smaller than the one demanded by the writer's original theory that some serious modification was needed. It is the purpose of this article to set forth the modified theory of the phenomenon which will account for such time intervals and the other effects observed, as well as some effects never accounted for in the theory of spark discharge. That a theory as obvious as this one to be described has not been proposed is quite surprising.

What is needed in a theory of spark discharge as it appears at this time is that (1) non-uniform potential gradients of high value can be generated in fields of the order of 30,000 volts between electrodes 1 cm apart, and (2) that such fields can be generated in 10^{-7} to 10^{-8} seconds.

For simplicity one may regard the conditions between plane parallel electrodes separated by 1 cm and over an electrode area of 1 cm^2 in air at atmospheric pressure. In such a volume of 1 cm^3 to which 30,000 volts potential difference have been applied there existed at the time of application some 1,000 pairs of ions due to the natural processes of ionization in the air. There are from 10 to 20 ions per cm^3 generated in air in a second due to radioactive and other causes and these are removed only by diffusion and recombination at such a rate that about 1,000 pairs of ions per cm^3 exist at any one time. Some of these ions are electrons, others are negative ions. The recent work of Cravath[16] has shown that in high fields negative ions lose their electrons by impact so that shortly after the appli-

[8] *Proc. Nat. Acad. Sci.*, 15: 259, 1929.
[9] J. J. Thomson, "Conduction of Electricity in Gases," Cambridge, 1906, p. 490 ff.
[10] L. B. Loeb, *Jour. Franklin Inst.*, 205: 308, 1928.
[11] *Phys. Rev.*, 33: 364, 1929.
[12] P. O. Pedersen, *Ann. der Phys.*, 71: 317, 1923.
[13] *Archiv. f. Electrotech.*, 16: 496, 1926.
[14] J. J. Torok, *Jour. A. I. E. E.*, 47: 177, 1928.
[15] J. W. Beams, *Jour. Franklin Inst.*, 206: 809, 1928.
[16] A. M. Cravath, *Phys. Rev.*, 33: 605, 1929.

cation of the field these negative ions are mostly in the electronic condition. Now these electrons are distributed at random in the cm³ so that each electron is on the average 1 mm or less from its nearest neighbor. As soon as the field is applied the electrons begin to move towards the anode at a velocity in this field of some 10^7 cm/sec as shown by the experimental studies of electron mobilities in air. The positive ions which the electrons create move only some 6×10^4 cm/sec towards the cathode. Each electron in such a field from Townsend's experimental data produces some 400 new electrons and ions per cm path under the conditions above. Thus since the electrons generate new electrons according to the equation $n = n_o e^{+\alpha x}$, where x is the distance covered in the gas and $\alpha = 400$, we see that the 1 initial electron in 1 mm path has resulted in the formation of e^{40} or 2.42×10^{17} new ions, provided it has traveled with undiminished velocity in this field. It is of course doubtful whether this magnitude will actually have been reached as the separation of the electrons from the slow positive ions will produce space charges that may act to retard or even stop the electronic motion. As the electrons advance towards the anode they spread apart owing to self-repulsion and diffusion so that the space charge on residual positive ions takes on a sort of wedge-shaped form with the broad end towards the anode. The pressure as well as the space charge determines the amount of spreading of the electron cloud, and the lower the pressure the wider the base of the wedge. The actual width of the spark discharge path must be an indication of this spreading, and it is well known how on reducing the pressure and increasing the diffusion the width of the spark path increases. Now if the initial electron were alone in the space between the electrodes the increase of ionization would probably largely cease as a result of the local annihilation of the field by the separation of space charges of electron and positive ion clouds. However, in moving this millimeter if the chance arrangement of initial electrons was propitious the negative cloud has approached the positive cloud of the next electron ahead. Thus the effects of the two positive space charges one behind and one ahead can offset each other somewhat, so that the electrons can continue to move and ionize and such an offsetting of the local field must occur from one electrode to the other before a spark can pass. When this fortuitous arrangement of initial electrons exists the conditions in the ion paths will be such that close to the cathode there will be a powerful positive space charge and close to the anode an approaching electron cloud with a succession of ion and electron clouds between. As a result of such actions the normal uniform fall of potential (shown as the straight line in Figure 1) will be replaced by some such a potential distribution as given by

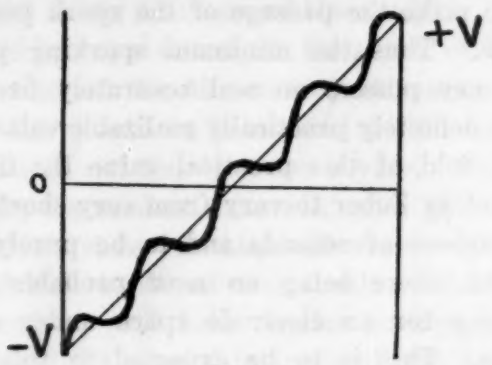

FIG. 1

the wavy line. It is seen that in this arrangement potential gradients many times steeper than the original line may result. In such fields $\frac{X}{p}$ may reach values ten to twenty times the value assumed from the uniform potential fall between the electrodes. Under such conditions positive ions can surely ionize by impact and furnish fresh electrons, especially near the cathode. Each such new electron generated by the positive ions can do much to improve the conducting path in the high fields obtained. From recent[17] experiments on recombinations of electrons with positive ions in gases at atmospheric pressure it appears that the phenomenon of recombination is so rare that the electron might easily move far into the positive cloud meanwhile ionizing without being neutralized. The calculation of electrical fields, such as described above, from theory is a well-nigh impossible task, but rough computations indicate that for space charges far smaller than those to be expected from the motions of electrons over 1 mm the volume charge of the positive ions alone could produce fields of the order hoped for. Until, however, such computations can be carried through the theory can only be considered as a promising suggestion.

The question of the time lag of the spark discharge is, however, nicely settled, for the initial electron can complete its path of 1 mm or probably less in 10^{-8} seconds since the electron velocity is easily of the order of 10^7 cm/sec. The theory also accounts in a simple fashion for the ordinary time lag of the spark. Recently Zuber and M. v. Laue[12] have investigated the time lag for the spark when *just* the minimum sparking potential was applied. This critical value is probably set by the value of the field to enable the electron and positive ion groups to approach the minimum distances for the proper production of ionizing fields for positive ions. Below such a critical potential, no matter how good the more probable fortuitous arrangements of initial ion dis-

[17] L. B. Loeb, Paper before the Am. Electro-Chemical Society, Toronto, May, 1929.

tribution may be, the occurrence of satisfactory arrangements of initial distribution will become so rare as to make the passage of the spark practically impossible. Thus the minimum sparking potential while it may possess no real accurately fixed value assumes a definitely practically realizable value. With a critical field of this practical value the time lags were found by Zuber to vary from very short periods up to numbers of seconds and to be purely chance phenomena, there being no most probable interval of time lag for an electrode space under ordinary conditions. This is to be expected to follow as a necessary consequence of the fortuitous arrangement, or coincidences, of ionized electron paths. Until such an arrangement occurs no spark takes place, and its occurrence is purely a chance phenomenon which is more or less probable. If this fortuitous occurrence happens to lead to an irregular path instead of an ionization straight across between the electrodes the spark takes on the well-known zigzag form. Introduction of electrons near the cathode such as by ultraviolet light or radium, which are for this phenomenon after all relatively few in number, insures the fortuitous arrangement being more probable and consequently makes the long irregular spark lags less likely, as well as possibly lowering the minimum value of the sparking potential slightly. That such illumination at the *cathode* is more satisfactory than elsewhere follows from the direction of motion of the electrons, with the correspondingly longer paths that they have in the direction of the anode.

When intense fields are used such as in the overvoltage experiments of Pedersen,[12], Rogowski,[13] Torok[14] and Beams[15] the critical field strengths for the building up of adequate space charges in proper relation to each other are so far exceeded that far less fortuitous arrangements suffice for sparking and the amazingly short time lags observed can occur.

It is hoped that this suggestion of the mechanism of spark discharge which qualitatively at least seems to explain the rather contradictory observed facts will serve to stimulate some one more gifted in the mathematical handling of such a problem to attempt its solution and thereby help us understand a phenomenon whose mechanism has been sought for since the time of Franklin.

LEONARD B. LOEB

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RESEARCH AT MELLON INSTITUTE DURING 1928–29

DIRECTOR WEIDLEIN in the sixteenth annual report of Mellon Institute of Industrial Research has summarized the progress during the fiscal year 1928–29, the eighteenth since the establishment of the institute at Pittsburgh. The expansion in all activities may be taken as an indication of the extent to which the American manufacturer has become research-minded.

The services which the institute has rendered to industries during the year are the cumulative efforts of 173 senior industrial fellows, industrial fellows, and assistants. A more tangible expression of their results is given by 159 publications, including 25 United States patents, which appeared during 1928. The funds paid to the institute during the fiscal year exceeded $800,000, an increase of nearly $100,000 over the payments for 1927–28. At the close of the year sixty-two distinct problems were under investigation.

The growth of the institute during the year was made possible by the acquisition through gift from the founders, Messrs. Andrew W. Mellon and Richard B. Mellon, of properties which have been altered extensively to provide additional laboratories and offices.

Important results in solving manufacturing problems, in extending uses for industrial products and in creating new products and new processes of manufacture were obtained in the following fields: fertilizers, organic solvents and resins, molded paper articles, insecticides, foods, chrome plating, ceramic products, insulation, kiln studies and vitreous enamel. The institute's previous investigations (1911–14) (1923–24) on the abatement of the smoke nuisance have received wide recognition. This research is of such great importance, not only to the city of Pittsburgh but to every city, that the work has been reestablished.

The yearly renewals of fellowships by the donors are a source of gratification, since the carrying out of extended investigations of industrial problems requiring long periods of time for their solution has been one of the chief aims of the institute from the time of its foundation. One fellowship has been operating continuously since 1911, and one since 1914. Ten fellowships have been maintained for more than ten years, and seventeen additional fellowships for five years or more. In spite of the increase in size of the physical plant, the institute, because of lack of space, has been unable to meet the demands made upon it, and during the past year has been forced to decline investigations of importance.

The Department of Pure Research has a valued function. This department aids the industrial fellows by acting in an advisory capacity, but its major importance lies in the disinterested investigation of problems not suggested by industry. Without pioneer work in pure science, to serve as source material for applied science, the progress of technology would languish.

The Department of Pure Research has conducted its investigations along the following lines: the preparation and standardization of organic compounds of boron to be used by medical specialists in research aimed at the relief or cure of epilepsy; the synthesis of new hypnotics related to barbital and luminal; the synthesis of new local anesthetics of low toxicity related to anesthesine; the preparation and study of the chemical and physical properties of the ethers of ethylene and propylene glycols, some of which have since been shown to have importance as industrial solvents. The more recent problems of the department have been concerned chiefly with a study of the acidic carbohydrates in plants. The chemical nature of alginic acid has been determined and the acidic nucleus of gum arabic has been shown to be an aldobionic acid closely related to carbohydrate derivatives produced by certain pathogenic bacteria.

Within the entire fiscal year, February 29, 1928, to February 28, 1929, the total number of Industrial Fellowships in operation was 72—22 Multiple Fellowships and 50 Individual Fellowships. Eleven fellowships were supported by trade associations. The 173 scientists working on these problems, classified by the colleges or universities from which they received their highest degrees, represent 45 institutions located in 27 different states.

During the eighteen years since the establishment of Mellon Institute at Pittsburgh the total amount of money appropriated by companies and associations was $5,820,164. The contributions to scientific literature comprise 15 books, 89 bulletins, 471 research reports, 898 other articles and 391 United States patents.

LAWRENCE W. BASS,
Executive Assistant

MELLON INSTITUTE OF
INDUSTRIAL RESEARCH,
APRIL 25, 1929

SCIENTIFIC EVENTS

THE ITALIAN ACADEMY

ACCORDING to *The Christian Science Monitor*, the Italian Academy, which was formally established by royal decree on February 7, 1926, will be officially inaugurated on October 28, next, the seventh anniversary of the Fascist Revolution.

The academy is divided into four classes of members, fifteen for each class, who are eminent in any of the following four branches: History and moral science, literature, the arts and natural science, physics and mathematics. There will be a president, four vice-presidents, one at the head of each class, a general secretary and a treasurer. These members will form the academic council and will remain in office for five years.

The first thirty members of the academy have been nominated by royal decree, on the advice of the Prime Minister and of the Minister of Education; the remaining thirty will be nominated within three years at the rate of not less than ten a year. Membership is for life; the academicians will enjoy privileges and rank of high state officials, will wear a special uniform and will receive an annual salary of 36,000 lire.

The academy will hold regular sittings to discuss and promote the general interests of art, natural science and letters. It will grant research subsidies, traveling scholarships and will contribute toward the completion of scientific, literary and artistic works; it will in some cases assign pensions to authors, artists and scientists and to their dependents. The academy will be housed in the beautiful Renaissance palace, La Farnesina, and will receive an annual subsidy from the state. The institution of the academy has met with general favor; the Edison Electric Company of Milan has recently presented to the academy a sum of 10,000,000 lire to provide scholarships for foreign travel and scientific research.

EXPLORATIONS IN ALASKA

THE results of further explorations are described in the U. S. Geological Survey Bulletin 797-B, by Stephen R. Capps, in which the geography and geology of the Skwentna River country are reviewed. The report is accompanied by a map on a scale of about four miles to the inch, on which the drainage and the distribution of the rock formations are shown.

In a new, unexplored country, where streams are too swift for boating and the only trails are those of the wild animals, the surveyor must still use the primitive methods of transport—the pack-horse and the boat dragged by hand through water too swift for even a modern power-boat. Both of these methods were used by the Geological Survey expedition that in 1926 undertook to extend topographic and geologic surveys into the upper portion of the basin of Skwentna River.

The Skwentna is a large western tributary of the Susitna River and drains a hitherto unexplored area in the heart of the Alaska Range south and east of Rainy Pass. The party of four camp hands in addition to the topographer and geologist, with 16 pack-horses and 2 tons of supplies and equipment, was divided into two parts. The pack train, with four men, was carried by launch and scow from Anchorage, on the Alaska Railroad, to the west shore of Cook Inlet, to travel over a trailless country to the upper basin of the Skwentna River. The other men, with most of the supplies, provided with a shallow-draft

boat and outboard motor, proceeded up the Susitna, Yentna and Skwentna Rivers, traveling by the use of the motor where that was possible, and wading and dragging the boat by hand through the miles of rapids. At the point where even this kind of boating was no longer possible the two parties joined and traveled southward up the Skwentna River into the very heart of the great mountain range. No human being was seen during a period of over two months, and even the few signs of native camps indicated that they were 20 or 30 years old. In September, when the approach of winter put an end to the work, the expedition retraced its own route to the coast.

As a result of the season's work about 700 square miles of hitherto unexplored territory was mapped geologically and topographically, and 350 square miles, previously mapped in an exploratory way, was remapped and corrected. This work gave a clue to the position and courses of the rivers that drain many thousand square miles of one of America's great mountain ranges and to routes of approach to other unexplored areas.

THE NEW POLICIES OF THE INDIAN BUREAU

THE policy of the Indian Bureau under the new administration has been considered by the Board of Indian Commissioners, created by Congress to advise it on Indian problems, and has been given general approval as announced by Secretary Wilbur. It is as follows:

The fundamental aim of the Bureau of Indian Affairs shall be to make of the Indian a self-sustaining, self-respecting American citizen just as rapidly as this can be brought about. The Indian shall no longer be viewed as a ward of the nation but shall be considered a potential citizen.

As rapidly as possible he is to have the full responsibility for himself. Leadership should be given the Indians rather than custodianship.

The Indian stock is of excellent quality. It can readily merge with that of the nation.

In order to bring this about it will be necessary to revise our educational program into one of a practical and vocational character and to mature plans for the absorption of the Indian into the industrial and agricultural life of the nation.

Decentralization of the activities of the bureau shall be brought about as rapidly as possible.

Viewed over a term of years, the Indian agent, as such, with his abnormal powers, shall be dispensed with.

In so far as it is feasible, the problems of health and of education for the Indians shall become a responsibility of the various states. Certain assistance for these purposes should be provided the states wherever it is equitable and desirable to do so.

New Indian schools should only be provided if it is not possible to merge the training of the Indian into the school system of the states. In so far as it is possible, scholarships in the institutions of higher learning of the country shall be provided for those Indian boys and girls who are capable of going beyond the ordinary high-school training.

The educational program for the Indians should be placed under the supervision of the Bureau of Education.

The health program should be placed under the Public Health Service.

In so far as it is possible, except on a few large reservations that are appropriate for a satisfactory life for the Indians, there should be continued allotment of land with full ownership rights granted to the Indians.

It shall be the aim to provide employment for Indians for all occupations possible in connection with Indian communities.

The general policy should be to increase the facilities for the care and development of the Indian for a short period of time, with the general plan in mind of eliminating the Indian Bureau within a period of, say, twenty-five years.

No new appointments should be made in the Indian Bureau except in following out the above program.

In so far as it is possible, general legislation and general appropriations from the Congress shall be sought, rather than specific legislation for specific Indian groups or to solve individual Indian questions.

A survey shall be made of all existing laws with which the Indian question is involved, so that proper laws can be drawn rescinding former actions which are no longer necessary, and an adequate legislative program developed for the future.

A HOMEOPATHIC MEDICAL CENTER

PLANS for a new homeopathic medical center at York Avenue and Sixty-third Street, New York City, which involve upwards of $19,000,000 in building funds and endowment, are announced by the board of the New York Homeopathic Medical College and Flower Hospital. More than $1,000,000 already has been subscribed through alumni support, and additional land adjoining the college and hospital site was purchased for $275,000 in April, assuring sufficient space for the development.

The development, which will make New York City the center of homeopathic education and research in this country, includes a project for research in the chronic degenerative diseases of middle age; a new home and training school for 250 nurses; a college dormitory for 225 students, and a new college building which will enable expansion of the undergraduate body to 400 students.

The main unit of the center, a new 300-bed hospital designed to allow for later expansion to 500-bed capacity, will rise fifteen stories. An initial effort to

raise $3,500,000 for its construction and endowment is now in progress. Completion of the hospital will inaugurate the medical center development, which will be carried out as rapidly as the necessary funds become available.

The architect's plans for the center were drawn by York and Sawyer in consultation with Dr. S. S. Goldwater, a specialist in hospital construction, and a committee of trustees and faculty headed by Dr. Claude A. Burrett, dean and director of the college and hospital.

The plans have been evolved in conjunction with a new five-point educational and research program which consists of increased emphasis upon the training of general practitioners, creation of an educational extension service for active physicians, enlargement of post-graduate facilities, and training of nurses for work in private homes as well as in institutions.

Regarding the research part of the program, Dr. Burrett recently said: "Progress in the control of infections and diseases of childhood has been remarkable and invaluable, but there is need for a concentrated, scientific attack on those diseases of the heart, kidneys and arteries, common among persons in the prime of life. Research at this institution in the future will be directed primarily toward this end."

The total amount of $19,913,000 necessary will comprise $8,975,000 for construction and equipment, and $10,938,000 for endowment.

PROFESSIONAL SALARIES

THE following resolution was passed at the general business session of the tenth annual meeting of the Southwestern Division of the American Association for the Advancement of Science, held at Albuquerque, New Mexico, on April 24:

WHEREAS, Such investigations as those of Dr. Peixotto, at the University of California, and of Dr. Henderson and his associates, at Yale University, afford convincing demonstration of the close relation between professional salaries, on the one hand, and standards of research and teaching, on the other; therefore, be it

Resolved, That the Southwestern Division of the American Association for the Advancement of Science in convention assembled in Albuquerque, New Mexico, April 24, 1929, does hereby urge the increasing attention of Congress, the states and the public to the problem of effective provision for more adequate salaries and facilities for scientific men, whether in the service of private foundation, state or federal government, to the end that the quality of research work may be improved and human welfare more effectively promoted; and, be it further

Resolved, That the Southwestern Division approve the taking of similar statistics in one or more of the state universities of our district to aid the sub-committee of the Committee of One Hundred in carrying forward their investigation; and, be it further

Resolved, That copies of this resolution be sent to SCIENCE, Dr. Rodney H. True, secretary of Committee of One Hundred on Scientific Research, American Association for the Advancement of Science, the permanent secretary of the American Association for the Advancement of Science, the congressional delegations of Colorado, New Mexico, Arizona and Texas, to Dr. J. Peixotto, University of California, Dr. Yandell Henderson, Yale University, and to the press.

SCIENTIFIC NOTES AND NEWS

THE honorary doctorate of laws was on May 8 conferred by the University of Paris on Professor Albert Einstein. This degree is said to be the first to be awarded since the war to a citizen of Germany.

THE honorary doctorate of science was conferred on Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, on the occasion of the dedication on May 11 of the new laboratory of anatomy and physiological chemistry of the University of Pennsylvania. Dr. Flexner, who was professor of pathology at the University of Pennsylvania from 1899 to 1903, made the principal address.

PUPILS and other friends of Professor William J. Gies have established at Columbia University the William J. Gies Fellowship in Biological Chemistry, the income from which for 1929–30 will be $1,500. Incumbents of the fellowship will be free to devote their time exclusively to biochemical research of their own selection. Inquiries regarding this fellowship, and applications for appointment to it in 1929–30, should be addressed, before June 30, to the department of biological chemistry.

A SUM of $10,000 has been given to the School of Tropical Medicine in San Juan, Porto Rico, for the creation of a fellowship fund to be known as the Bailey K. Ashford Fellowship Fund. It is the purpose of the donor that this fund shall be used to support research on problems pertaining to tropical medicine in Porto Rico. In case the funds are not used as a fellowship it is the wish of the donor that they be used as a prize for meritorious work in the field of tropical medicine. The trustees of the University of Porto Rico and representatives from Columbia University have appointed the following committee to administer the fellowship: Dr. Jas. W. Jobling, Dr. Frederick P. Gay, Dr. Bailey K. Ashford, Dr. José Belaval and Dr. Earl B. McKinley.

AT the meeting of the National Research Council, held in Washington last week, Dr. Dayton C. Miller was reelected chairman of the division of physical research. This is the third year that he has held this office.

DR. LEWELLYS F. BARKER, professor emeritus of medicine of the Johns Hopkins University, was elected chairman of the Medical Council of the United States Veterans Bureau to succeed Dr. Ray Lyman Wilbur, Secretary of the Interior.

DR. STEPHEN TABER, professor of geology at the University of South Carolina, was elected president of the South Carolina Academy of Science at the annual meeting which was held on March 30. Other officers elected were Dr. R. N. Brackett, Clemson College, *vice-president*, and Dr. G. C. Mance, of Winthrop College, *secretary-treasurer*.

THE American Association of University Women has awarded the Sarah Berliner fellowship to Dr. Sally Hughes-Schrader, of the department of biology of Bryn Mawr College.

THE Adams Prize of the University of Cambridge for 1927–28 has been awarded to Professor Sydney Chapman, of the department of mathematics in the Imperial College of Science and Technology, London. The value of the prize is about $1,000. The subject set was "The Variations in the Earth's Magnetic Field in Relation to Electric Phenomena in the Upper Atmosphere and on the Earth."

THE Paris Academy of Medicine has awarded the Prince of Monaco prize of 100,000 francs to Professor Borel, of Strasbourg, for his work on the etiology of cancer.

SIR ALFRED EWING, principal and vice-chancellor of the University of Edinburgh, has been elected an honorary member of the Institution of Civil Engineers in recognition of his educational and scientific services.

THE Royal Medals of the Royal Geographical Society have been awarded as follows: The Founder's medal to Mr. Francis Rennell Rodd for his "Journeys in Air" and his studies of the Tuareg people; the Patron's medal to Mr. C. H. Karius, assistant resident magistrate, Papua, for his crossing from the Fly River to the Sepik. The following awards have also been made: The Murchison Grant to Mr. C. S. Elton for his three seasons' study of the distribution of life in Spitzbergen; the Back Grant to Mr. C. P. Visser for his exploration of the Hunza-Karakoram glaciers; the Cuthbert Peek Grant to Mr. Donald Cameron for his journey across the Sahara from Nigeria to Algiers; the Gill Memorial to Mr. George Dyott for his recent expedition in search of Colonel Fawcett.

THE council of the British Institution of Civil Engineers has made the following awards in respect of papers read and discussed at the ordinary meetings during the session 1928–29: A Telford gold medal and a Telford premium to Mr. Conrad Gribble, London; a George Stephenson gold medal to Mr. Harry Hall, London. Telford premiums to Messrs. H. N. Colam, London; F. W. A. Handman, London; T. P. M. Somers, Glasgow; H. V. C. Johnstone, Sudan, and jointly to J. H. Hyde, Twickenham, and H. R. Lintern, Teddington.

Nature writes: "After fifty years in the service of the Royal Institution, Mr. Henry Young is about to retire from his post as assistant secretary and keeper of the library. He was engaged as an assistant in the library in 1879, when Tyndall was the resident professor, and was promoted ten years later to the position which he now occupies. He has been a devoted servant to the institution and a familiar friend to a large number of the members. The Royal Institution is full, as is well known, of interesting and honorable traditions, and Mr. Young has been and still is one of the chief agents of their preservation. In his place Mr. Thomas Martin, at present secretary to the institute of physics, has been appointed general secretary; Mr. Ralph Cory, assistant in the library, becomes librarian."

SIR ALBERT E. KITSON, director of the British Geological Survey on the Gold Coast, has retired after twenty-one years' service on the West Coast of Africa and has returned to England.

PROFESSOR H. B. WILLIAMS, of Columbia University, delivered the principal address at the initiation exercises of the Virginia Chapter of Sigma Xi, on May 1. On this occasion the President and Visitors Research Prize of $100 in gold was awarded to Professor Joseph K. Roberts for his article "The Triassic of Virginia," which was judged to be the best scientific paper published from the university during the year 1928.

THE Pasteur Society of Central California held a dinner meeting in San Francisco on May 1. The speaker was Dr. W. H. Manwaring, professor of bacteriology and experimental pathology at Stanford University, who spoke on "Immunological Prophecy from Ancient Hieroglyphics."

PROFESSOR W. H. WRIGHT, astronomer in the Lick Observatory, will lecture before the Astronomical Society of the Pacific on May 20, on "Photographs of the Planets by Light of Different Colors."

DR. EDWARD W. BERRY, professor of paleontology and historical geology at the Johns Hopkins University, delivered an illustrated address on "The History of the Andes" before the Washington Academy of Sciences on May 10.

DR. DAYTON C. MILLER, head of the department of physics of the Case School of Applied Science, gave an evening address on May 3, under the auspices of

the Nebraska Academy of Sciences. His subject was "The Science of Musical Sounds." The address was accompanied by demonstrations of the Phonodeik and musical instruments. On May 4 he gave an address before the Science Colloquium of the University of Nebraska on "Ether-drift Experiments and Relativity," with demonstrations.

DR. WILLIAM H. HOBBS, of the University of Michigan, will be the commencement speaker at the Worcester Polytechnic Institute on June 13. The subject of his address will be "Engineering and Polar Exploration."

DR. BAILEY K. ASHFORD, Colonel U. S. A., retired, professor of mycology in the School of Tropical Medicine, San Juan, Porto Rico, has been requested by the executive council of the Association of Military Surgeons to deliver the Kober lecture at Georgetown University.

THE Edward K. Dunham lectures for the promotion of medical sciences will be given at the medical school of Harvard University at 5 o'clock, May 20, 22 and 24, by Dr. Louis Lapicque, professor of general physiology at the Sorbonne, Paris. The general subject will be "Chronaxie." Previous lecturers have been Dr. Willem Einthoven, of the University of Leyden; Professors Ross Granville Harrison, of Yale University; Richard Willstätter, of the University of Munich, and Sir Charles Scott Sherrington, of the University of Oxford.

As a memorial to the late Alfred Dodge Cole, formerly professor of physics at the Ohio State University, it is planned to collect a fund of $50,000 to establish a library of physics as part of the university's Mendenhall Laboratory of Physics. Professor Cole's collection of scientific books has been given to the laboratory. The project is in charge of a committee of which Dr. Michael I. Pupin, Dr. Robert A. Millikan and Charles F. Kettering are members.

A MEETING in memory of Mr. Frederick T. Gates was held at the Rockefeller Institute for Medical Research on May 15, at which the speakers were Mr. John D. Rockefeller, Jr., Dr. William H. Welch and Dr. Simon Flexner.

DR. EARLE MELVIN TERRY, professor of physics at the University of Wisconsin and a member of the department of physics since 1902, died at his home of acute heart failure on May 1.

ALVIN CASEY BEAL, professor of floriculture at Cornell University for more than twenty-five years, has died at the age of fifty-seven years.

DR. ROBERT BAIRD RIGGS, Scoville professor emeritus of chemistry at Trinity College and a member of the college faculty for thirty-three years, died on May 11 at the age of seventy-four years.

C. HERBERT BELANSKI, of the department of geology of the State University of Iowa, died on April 30, aged thirty-one years.

THE tercentenary of the birthday of Christiaan Huygens was celebrated at Leyden in April, the commemoration being organized by the Royal Academy of Science, in conjunction with the Senate of the University of Leyden and various scientific associations. Speeches were delivered by Dr. van Itallie, M. van Vollenhoven, Dr. P. Zeeman, Dr. A. J. Holleman, Dr. C. A. Crommelin and M. E. Piccard, tributes being paid to Huygens as the discoverer of fundamental laws of mechanics. It is proposed to publish in Amsterdam a souvenir containing reports of the speeches, with an account of the celebrations.

A LUNCHEON of the American Institute held in cooperation with the Exposition of Chemical Industries, New York City, was given at the Hotel Commodore on May 11. Dr. Ellwood Hendrick, curator of the Chandler Chemical Museum, Columbia University, presided. He stressed the need for "a concept of research" as part of the equipment of business executives. Dr. Arthur D. Little, president of A. D. Little, Inc., spoke on "Science—the Fifth Estate"; Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry,* discussed "The Dollar Value of Chemical Research"; Dr. W. E. Emley, of the Bureau of Standards, spoke on "The Utilization of Farm Products in Industry," and Dr. C. E. Kenneth Mees, research director of the Eastman Kodak Company, spoke on the development of paints, varnishes, oils, anti-knock gasoline and other products.

A WORLD Congress on the History of Science, under the auspices of the new International Academy for the History of Science, will meet in Paris, May 20 to 25. Its chief business will concern international cooperation in compiling the history of the sciences. Organizers of the congress include: Abel Ray, of Paris; George Sarton, Belgian-American scholar and editor of *Isis;* Professor Henry E. Sigerist, of the Medical Institute of Leipzig; Professor Charles Singer, of the University of London; Karl Sudhoff, medical historian and former president of the Medical Institute of Leipzig, and Professor Lynn Thorndike, of Columbia University.

AN Associated Press dispatch reports that Dr. Jacob Gould Schurman, the American ambassador to Germany, was one of the chief speakers at a gathering on May 8 on the occasion of the dedication of the new Harnack House of the Kaiser Wilhelm Society

for the Advancement of Science. Foreign Minister Stresemann and President Adolf von Harnack also spoke. Ambassador Schurman is reported to have called Harnack House, which will be used as a residence for foreign scientists at the Society's Research Laboratories, "an agency for the promotion of international understanding." President von Harnack celebrated his seventy-eighth birthday on the same day.

ONE of the sessions of the coming meeting of the Botanical Society of America, to be held at Dartmouth College, Hanover, N. H., June 25–28, is to be devoted to cytology and genetics. No formal papers are to be read, but the meeting will be in the form of an exhibition and informal discussion of current research. All geneticists and cytologists who are planning to attend this meeting are urged to bring with them preparations, specimens, charts, etc., illustrating their own work, and to take part in the exhibit. Arrangements for space, microscopes, etc., should be made in advance, by communicating with Dr. Ralph E. Cleland, Goucher College, Baltimore, Md.

THE library of William J. Gies, professor of biological chemistry at Columbia University, consisting of more than 5,000 volumes, chiefly in biological chemistry and dentistry, has been presented by him to Columbia University for the use especially of the medical and dental schools, and is now contained in the library at the Medical Center.

FIELD MUSEUM OF NATURAL HISTORY, Chicago, has received by bequest the herbarium of the late Robert Ridgway, consisting of more than 4,000 specimens of plants from the region of Richland County, Illinois. The collection is particularly rich in critical groups of trees, such as the hawthorns and hickories, and forms an important addition to the Illinois herbarium maintained by the museum.

PROFESSOR CHARLES H. RICHARDSON, head of the department of mineralogy at Syracuse University, has formally transferred his mineralogical library to the university. The gift comprises more than 10,500 books, bulletins, separates, etc., together with SCIENCE complete to 1898, *Chemical Abstracts, Journal of Chemistry, Industrial and Engineering Chemistry, Journal of the Mineralogical Society, Journals* of the American Mining Congress and the Institute of Mining and Metallurgical Engineers. The gift was made on May 4, the twentieth anniversary of the founding of the department of mineralogy, the twenty-third anniversary of the appointment of Dr. Richardson to the faculty and the forty-third year of his teaching.

THE International Committee for Phytopathology and Economic Entomology, T. A. C. Schoevers, secretary, Nassauweg 28, Wageningen, Holland, announces that two Eriksson prizes are offered for the two best memoirs, giving an account of new and original work on (1) Investigations on Rust (Uredineae) Diseases of Cereals (wheat, oats, barley or rye). (2) Investigations on the rôle played by insects or other invertebrates in the transmission or initiation of virus disease in plants. The value of each prize will be 1,000 Swedish crowns. Competitors may be of any nationality.

WE learn from *The British Medical Journal* that the Garton prize and medal has been instituted by the Grand Council of the British Empire Cancer Campaign for subjects of the empire, with the object of promoting research into the nature, causes, prevention and treatment of cancer. A medal, together with an honorarium of £500, will be awarded early in 1932 to the person or group of persons who shall submit the essay embodying the results of original investigations which, in the opinion of the judges appointed by the council, is the best contribution towards the early diagnosis of cancer.

THE Julius Rosenwald Fund will contribute $50,000 a year for five years to support the University of Chicago clinics on condition that $100,000 a year be raised from other sources; Max Epstein and Albert D. Lasker each pledged $25,000 a year for five years. John Hertz has given the university $75,000 for a study of disorders of the pituitary gland and related conditions. The Quaker Oats Company has granted $4,500 for an investigation of the nutritive value of unirradiated and irradiated farina and the effect of ultraviolet rays on the various types of proteins; it has granted $3,600 for a study of certain properties of cereals treated with ultraviolet rays. The following contributions have been made to the library fund of the Billings Hospital: Dr. Frank Billings and Mr. C. K. G. Billings, Mr. Charles Ruddock and the Knapp Fund each $1,000, and Dr. Lester E. Frankenthal, $257.24.

PROFESSORS C. K. LEITH and W. J. Mead, of the University of Wisconsin, conducted twenty-five graduate students in geology through the pre-Cambrian mining districts of Minnesota and Michigan from May 10 to 20.

PROFESSOR BERT HUDGINS, of the department of geography of the College of the City of Detroit, will conduct a transcontinental field course for Clark University from July 1 to August 23. The trip will be made as a bus party leaving Worcester and going by Washington, D. C., Knoxville, Memphis, to Grand Canyon and Los Angeles, and returning by a northern route taking in Yellowstone National Park and the Black Hills. Mrs. Hudgins will chaperone.

A COMMISSION of specialists plans to spend four months this summer investigating conditions in Russia and Siberia. The tentative personnel of the commission includes: Franklin S. Harris, president of Brigham Young University, Provo, Utah, chairman and agronomist; J. B. Davidson, Iowa State College, agricultural engineer; Benjamin Brown, North Carolina Agricultural College, poultry and marketing specialist, and K. B. Sauls, secretary. Others may be added to the group. The Russian government is planning to set aside a tract of ten million acres in Siberia where Russian Jews are to be colonized in order that they may have complete religious and industrial freedom. The Russian government is asking wealthy Jewish people in America to aid in the project. Before the backers consent they wish to obtain first hand information on the condition of members of their race in Russia and the nature of the land in Siberia.

Nature reports that a summer school of biology, under the direction of Professor F. A. E. Crew, is being organized by the Education Committee for the County Borough of Brighton, to be held at the Municipal Training College from August 2 to 16. Courses will be given on biology and the school curriculum (Professor A. D. Peacock, University of St. Andrews, and Mr. G. B. Walsh, High School for Boys, Scarborough), on the theory of the cell, the gene and organic inheritance in man (Professor F. A. E. Crew), and there will be single lectures on special topics. Practical and field work is being arranged. Particulars can be obtained from the secretary to the Brighton Education Committee, Mr. F. H. Toyne, 54 Old Steine, Brighton.

THE foundation stone of the International Hydrographic Bureau was laid at Monte Carlo on April 20 by the Prince of Monaco in the presence of the delegates of the International Hydrographic Conference and many prominent members of the British colony. The building is to be erected on the Quai de Plaisance. The Marchese Paulucci di Calboli, assistant secretary-general to the League of Nations, expressed the satisfaction with which the offer of the Principality of Monaco to provide such a suitable site for the International Hydrographic Bureau had been received by the Council of the League of Nations. The Marchese recalled that in July, 1919, when it was decided to provide a permanent bureau, Monaco was chosen because of its associations with the late Prince of Monaco, the founder of the Oceanographic Museum, who had contributed during his lifetime such valuable assistance to the furtherance of oceanographic research. On behalf of Sir Eric Drummond, secretary-general to the League of Nations, the Marchese tendered his thanks to the Dynasty of Monaco.

UNIVERSITY AND EDUCATIONAL NOTES

THE General Education Board of the Rockefeller Foundation of New York has offered to Harvard University a conditional gift of $400,000 to construct a laboratory for physics. The gift is offered subject to raising by the university of an additional $600,000.

ANNOUNCEMENT has been made at the University of Virginia that the anonymous gift of a trust fund of $6,000,000 for scholarships and fellowships made last year was from the late Philip Francis du Pont, who was a student at the university from 1897 to 1900.

TWO gifts for the study of the structure of the brain have been received by Yale University. Harry Payne Bingham has placed at the disposal of the department of anatomy the duplicate specimens in his unique collection of fishes deposited in the Peabody Museum, and Mrs. Dudley S. Blossom, of Cleveland, has subsidized the study by a grant of $5,000 a year for five years.

The Boston Evening Transcript reports that the Sargent School of Physical Education has been transferred to Boston University by Dr. Ledyard Sargent, president and owner, and will become a part of the Boston University school of education under the direction of Dean Arthur H. Wilde.

ON the occasion of the presentation of the freedom of the city of Edinburgh to Sir Alfred Ewing, principal and vice-chancellor of the university, he read a letter from Sir Alexander Grant, enclosing a check for £25,000 towards the building of a new department of geology, and promising a like amount within twelve months. This, he said, was in addition to a sum of £50,000 given to the university by Sir Alexander Grant a few years ago.

PROFESSOR FRED W. UPSON has been appointed dean of the graduate college of the University of Nebraska. He will retain the chairmanship of the department of chemistry, which he has held since 1918.

DR. E. U. CONDON, assistant professor of physics at Princeton University, has been appointed professor of theoretical physics at the University of Minnesota.

PROFESSOR J. H. BODINE, of the department of zoology of the University of Pennsylvania, has been appointed head of the department of zoology at the State University of Iowa. He succeeds Professor W. W. Swingle, who goes to Princeton University.

DR. PERCY EDWARD RAYMOND, since 1917 associate professor of paleontology at Harvard University, has been promoted to a professorship.

DR. W. H. ADOLPH, who has served the past two years as associate professor of chemistry in the Uni-

versity of Nebraska, will return to China in the autumn as professor of biochemistry at the Yenching University at Peking.

PROFESSOR J. E. HAWLEY, of the University of Wisconsin, has been appointed head of the department of mineralogy at Queens University. He is a graduate of Queens and succeeds Professor E. L. Bruce, who takes the Miller Memorial Research Chair in Geology.

DISCUSSION

AMBITIOUS AGRONOMY

ORGANIZATION is the slogan of to-day; mass production is typically American. Surely no carping critic could do less than admit that the American Society of Agronomy is achieving its full 100 per cent. of United States modernism. Not content with sloughing off even the suspicion of representing an art rather than a science or with establishing an excellent scientific journal or with the enrolment of a large and enthusiastic membership, the agronomists now seem ready to assume control of the evolution of our mother tongue.

When a committee comprising a university president, a university professor and a head of a large office of a large government bureau issues pronouncements designed to bring about extensive changes in the English language, and the American Society of Agronomy accepts these reports and indorses them, at least by implication, by continuing this committee on agronomic terminology, the question now may be: Is it necessary to organize a Society Opposed to the American Society of Agronomy or will ridicule erase the effects of such well-intentioned blundering?

A year ago the first detailed part of the committee report[1] set forth a motley crew of adjectives, "median terms"—illogical, carelessly constructed, poorly if at all defined, confusing rather than an aid to concise scientific expression, and generally undesirable.[2] A few samples are quoted from the lists in the report:

midlow	midplumpth
midheight	midlux
midhigh	midumblux
midthickth	midrugaplane
midstraighth	midceptisist
midcoolth	midceptimmune
midgoodth	midstouth

Rather especial attention should be given to *stouth*, the proposed basic term from which the word "midstouth" was made. In answering a criticism to the effect that *stouth* was a word with a meaning entirely different from that proposed by the committee, the chairman of the committee has stated:[3] "As the committee pointed out . . . 'stouth' is not a new word but an old term having exactly the meaning of stoutness." Perhaps the committee can submit more definite evidence regarding the connotation of these two words than a dogmatic statement from its chairman. Our leading dictionaries, such as Century, Webster's International, and Standard, however, have failed to discover the common use of *stouth* meaning stoutness. The words *stout* and *stouth* are derived from quite different sources, and at least from the beginning of the fourteenth century to the present time even the derived meanings in "common use" have never been interchangeable. Throughout this period *stouth* has carried the idea of theft, stealth, etc., but never stoutness; *stout* has meant proud, valiant, hardy, thick in body, etc., but even with the variant spellings up to the present time it seems never to have been confused with *stouth*. The second part of the last year's report[4] urges mass action in simplification and standardization of plural forms of Latin words with the plea of greater efficiency in instruction of the young.

Of course no attention would need be given to these reports were they fathered merely by an individual. They become important solely because the American Society of Agronomy seems impressed by its impressive committee. Probably no group of technical men in the United States is publishing more per man year than the agronomists. These agronomically standardized evolutions will soon, therefore, be firmly intrenched in the respectability of "dictionary usage" unless agronomists as well as others can be stimulated to thoughtful review of language building in general and in particular of the character of the recommendations or the creations of the committee. For example, in the second report two new words, "phytoleum" and "zooleum," are suggested. Although the report seems to state that these words were constructed to be "similar" to the trade names *congoleum* and *linoleum*, it may be assumed the committee in-

[1] Carleton R. Ball, Homer L. Shantz and Charles F. Shaw, "Median Terms in Adjectives of Comparison," *Journal of the American Society of Agronomy*, 20: 182–191. 1928.

[2] K. F. Kellerman, "Criticism of the Report of the Committee on Agronomic Terminology," *Journal of the American Society of Agronomy*, 20: 519–522. 1928.
J. H. Kempton, "Agronomic Jabberwocky," SCIENCE, 67: 629–630. 1928.
H. A. Allard, "Words and Life," SCIENCE, 69: 41–43. 1929.

[3] Carleton R. Ball, "Comment on Dr. Kellerman's Criticism of the Committee Report on 'Median Terms,'" *Journal of the American Society of Agronomy*, 20: 523–526. 1928.

[4] Carleton R. Ball, "English or Latin Plurals for Anglicized Nouns" (A contribution from the Committee on Agronomic Terminology), *American Speech*, 3: 291–325. 1928.

tended to express the hope that these two, together with the well-known word *petroleum*, might establish domination over the oleaginous world. I suggest that *petroleum* is a Latin derivative, whereas the two new proposals are Greek-Latin hybrids that I believe scholars will advise American authors to avoid.

Lack of linguistic background is also indicated by such curiosities as the failures to realize that *rex* is the phonetic result of *reg+s*; and *lex*, of *leg+s* ("Exceptions . . . are such words as *lex* and *rex* . . . of which the plurals . . . end in *-ges*. . . . Attention has already been called . . . to the irregular formation of the plurals of . . . *lex* . . . *rex* . . ."); or that, while *mater* and *mother* are cognate, *mothers* was not derived from *matres* but is strictly English and quite unsuitable to offer as an "Anglicized plural" of *mater*. No clues to the best method of writing a plural of *alma mater* have been discovered in the report.

To add a lighter touch, I can not forego noting the naïve pun in the suggestion of simplification for *facies, series,* and *species,* ". . . the desirable action in the case of these nouns is to change, not the plural, but the singular, by dropping the final *s* and thereby creating a form truly singular in appearance."

As noted before, the committee appears to be permanent and to carry a certain indirect indorsement from the society even for its unpublished and unfinished ideas. In the January, 1929, issue of the *Journal of the American Society of Agronomy* is printed a short report[5] as a keynote of an eventual more complete statement happily not yet in evidence. This brief recent report is perhaps the most startling of the three. The committee now seems to be specializing in infinitives and past tenses, for example:

> The past tense of many hundreds of similar verbs has only the one meaning of indicating the possession of the article or quality named.
>
> That this is the common usage is indicated in several other ways than by the use of the past tense. . . .
>
> In contrast to the many hundreds of words in which the infinitive or the past tense indicates the possession of the article or quality named in the root. . . .

I doubt whether any intelligent reader of the report can avoid concluding that the committee has confused the past tense and the past participle. If the committee had experimented with irregular verbs with their differences in form for past tense and past participle, concentration upon past tenses might not have received such wide publicity.

[5] Carleton R. Ball, *chairman*, Homer L. Shantz and Charles F. Shaw, "Report of Committee on Terminology" (report presented at the annual meeting of the Society held in Washington, D. C., on November 22, 1928).

The word *dehulled* is featured. I admit regretfully that our own bureau is partly if not entirely to blame. About ten years ago the bureau began to use *dehulled* to avoid the confusion that was claimed to arise when varieties of barley with and without hulls were discussed. In subsequent years the use of *dehulled* has been extended somewhat, without much further thought or discussion. With a bureau publishing as largely as ours, and with close contacts with many state agricultural colleges, it is easy to see how not only papers dealing with barley but also those dealing with other cereals should soon bristle with the prefix *de-*, and the adjective *hulled* should sometimes mean with hulls on, and at other times should mean with hulls removed.

Elsewhere[6] I have suggested the use of the nounal adjective *hull* in place of the participial adjective *hulled* in describing barley that retains the hulls. For example, there is no objection to having black-*hull* barley hulled, though it does seem foolish to have black-*hulled* barley hulled. Omitting the adjective *black* makes the contrast even better. Hull barleys, then, will not be confused with hull-less barleys. Whether or not this simple suggestion for solving the problem of the agronomist's *de* will be "recognized by the dictionaries," I prefer to leave to the dictates of good usage, guided if possible by the advice of specialists in philology rather than in agronomy.

That it is often desirable to add new words or to make other changes in a language is beside the question. All writers favor coining new words when they are needed, or otherwise aiding in language growth. The requisites of conciseness, clearness and exactness of definition, and suitability and propriety of words or plans should be uppermost, however, in the minds of any language amateurs. No one scientific or technical group, furthermore, should try to change our language except to the extent essential for accuracy, brevity and facility of expression of the technicalities peculiar to that group.

In all probability the American Society of Agronomy has been acting carelessly or thoughtlessly under the pressure of its enthusiastic committee on agronomic terminology. Whether this brief outline of some of the unfortunate features of the committee point of view will lead to more sober second thoughts only time can tell.

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THE EUROPEAN STARLING IN ILLINOIS

THE European starling was introduced into the United States about 1890, and since that time has spread rapidly westward until its western limits are

[6] K. F. Kellerman, "'Hulled' and 'Dehulled,'" *American Speech*, 4: 186. 1929.

now Iowa and Kansas. The first report of the starling in Illinois was apparently that of Professor Frank Smith, of the University of Illinois, in 1922. These were observed by Professor Smith and the writer, and an attempt was made to secure several specimens, but without success. The latest report gives eight records for Illinois.[1] Of these records, only two are of specimens taken and preserved, at Quincy and Godfrey on the Mississippi River.

That the starling has become a resident of Illinois is fully attested by its presence with large flocks of the bronzed grackle. Every year local reports are received of the presence of the bird in Urbana and vicinity. Recently (January 5) five starlings were brought into the museum by Mr. Reinhold Bialeschki, living on a farm at Sodorus, Champaign County, where they were found roosting with pigeons in the evening. Mr. Bialeschki reports that they were captured by hand after dark. They were in fine winter plumage, and there appeared to be four males and one female. More recently, a specimen was brought in by Miss Dameier on January 17, from Lena, Stephenson County, near Freeport. This is in the northwestern part of the state and is farther west than the previous records from the northern part of the state. While winter records are becoming common, spring and summer records are rare, although a pair are recorded as having bred at Texico. The specimens noted above have been incorporated in the research collections of the university museum.

The five specimens from Sodorus were kept alive for several days. They were confined in a sparrow trap in which entrance could be made only by the small door at the trap and this opened *inward*. On the second day myself and family were away from the house for several hours in the morning, returning early in the afternoon. What was our surprise to discover three of the five birds flying about the house. It was later observed that the birds had learned that the door could be pulled inward and had thus been able to force the door open far enough to squeeze out of the cage and escape by the space in which the balanced trap operated. Later a heavy cloth was placed over this end of the cage, but even this did not prevent several birds from escaping. To the students of animal behavior this is interesting as an example of comparative intelligence in birds. During their captivity, every wire in the trap was pulled and twisted in an attempt to get out, and this method probably caused the discovery of the movable door.

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[1] See Cooke, Circ. 40, U. S. Department of Agriculture, November, 1928.

DISPERSED STAGES OF THE STIGMA IN EUGLENA

SOME observations on the stigma of *Euglena gracilis* and *Euglena* sp. are of interest in connection with the commonly held view that such organelles of flagellates are modified chloroplasts, and that they divide during fission of the organism (Klebs) or may be formed *de novo* in one of the daughter cells (Korshikov). In flagellated forms of *E. gracilis* the stigma varies in diameter and thickness, and in size and number of its component granules. The granules may be large and few in number, or they may be numerous and so small that it is difficult to resolve them optically. The stigma, therefore, is not constant in structure in the species examined, and seems rather to be a loose aggregate of pigment granules of various sizes, possibly embedded in some sort of a homogeneous matrix. In non-flagellated ("division-cyst") stages of *E. gracilis* a number of reddish-orange granules are often seen in the inter-alveolar spaces; these are identical in color and similar in size to the granules of the stigma in flagellated stages. In some cases most of the granules are grouped in a loosely granular mass comparable in appearance to a somewhat diffuse stigma. In cells without such aggregates the granules are widely scattered. A "condensed" stigma like that of the flagellated form has not been observed in division-cysts. These facts point to the occurrence of a dispersed phase of the stigma in the life-cycle of *E. gracilis*.

The junior author, in continued observation of living flagellates, has traced the stigma through binary fission in *Euglena* sp. In the prophases the stigma breaks up into its component granules, which become scattered through the cytoplasm. In metaphase or early anaphases the granules become rearranged in two loose aggregates, one near each daughter gullet. These two aggregates persist through later anaphases and telophases, and give rise to a definitive stigma in each daughter organism.

If Grasse's view, that the stigma of Euglena represents the Golgi apparatus, be accepted—and its reaction to methods for demonstration of the Golgi apparatus supports such an interpretation—these observations afford an example of change in form of the Golgi apparatus in a free-living flagellate. In one species this involves a breaking up of the definitive Golgi apparatus into discrete granules in binary fission, followed by a rearrangement of the granules into two aggregates, one in each daughter organism. In the other species, there is a dispersal of such granules, varied with the formation of loose aggregates, in the non-flagellated division-cyst stages.

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VIBRATIONS AND PARTICLES

PROFESSOR COMPTON in *The Scientific Monthly* for April tells us that light is alternately a particle and a vibration. Would it not interest some of your readers if some physicist would now tell us why it can not be a particle and a vibration at the same time? Some minds are so constituted that they like not only to have an explanation of why a thing is so, but also a further explanation of why it is not something else. This is particularly true when one is unable to picture the first in one's mind, and the second is obvious.

Thus imagine water dripping from a swinging hose, resembling plane polarized light of a single wavelength. If we seize the hose and shake it irregularly we should have ordinary light. Or again, if instead of letting the hose swing, let the spheroidal drops change their ellipticities in various directions. These simple suggestions must have already occurred to many minds. In what way do they fail to satisfy recorded observations so completely that it is necessary to adopt a solution that it is difficult or impossible to conceive? It is quite possible that this matter has been treated in full elsewhere, but many of your readers do not have access to all the technical magazines, and I think a simple statement by some one in authority might be of general interest.

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QUOTATIONS

THE CENTENARY OF THE LONDON ZOOLOGICAL GARDEN

ONE of the most famous institutions in the whole world—the Zoo—keeps its centenary to-day; but perhaps no formal celebration will be able to do justice to the place which the Zoo has made for itself in the national life. When history has recorded its progress, and science assayed its services to zoology and kindred studies, there remain influences and consequences much less amenable to statistics—an immense sum of human enjoyment, a vast body of popular literature, innumerable pictures and drawings serious and light, a continuous stream of humor, pathos and allegory of which the Zoo has been almost from the first an unfailing source. Of what other comparable institution can anything like the same be said? The honored originator of the Zoo, Sir Stamford Raffles, though he died before the gardens were actually opened, could have as little foreseen the developments of his new world as Columbus foresaw modern America. The centenary coincides with the highest peak of the Zoo's prosperity, for its rate of growth, when measured by income and numbers of fellows and visitors, has been in the last nine or ten years out of all proportion to the past. For this no doubt there are several causes, and they interact upon one another; but among them must certainly be reckoned good business management, the full recognition (though not until after a long struggle) of the value of light and open air for animals in captivity, with the consequent abolition of old, dark and airless places of confinement, the establishment of special new buildings like the aquarium and the reptile house, and the greater mobility of the age which enables many more visitors to go to Regent's Park than before, and so to bring in the resources necessary for improvements. The Zoo is unrivaled for the variety of specimens which it contains. It has developed, moreover, in a typically English way, for alone of important national collections of animals it receives no state subsidy. A few friends of zoology got together in the first place, formed a society and induced the government of the day to grant them a site on crown land; ever since then the Zoological Society has managed its own affairs, paid rent and rates, and lived entirely on subscriptions of the fellows, bequests and entrance fees. By its charter it can divide no profits; whatever it earns goes to the benefit of science and popular spectacle, and, as every one knows, its present prosperity is about to lead to new extensions on a much larger acreage at Whipsnade.

Through its hundred years the Zoo has, of course, been something much more than an exhibition of animals. The Zoological Society was founded for scientific purposes, and it has served them steadily. It now owns one of the most catholic libraries of zoology in existence. Its output of learned literature has been unceasing; its research continuous; its response to the calls made upon it prompt. The zoology, it need hardly be said, which was familiar to its founders is not the zoology of to-day. One of the projects which Raffles and his contemporaries had in mind was the domestication of more animals; here, however, zoology has been able to do next to nothing, for at best domestication at the Zoo means the taming of wild animals and not the creation of such conditions as will allow them to breed freely. In this respect, therefore, the dreams of the founders may be said to have been fruitless. In other respects the developments of science have outstripped their program. The zoology of their time, though systematic in its way, was in some aspects nearer that of Pope in his Essay than to Darwin's: the contemplation of the forms of life led directly to a natural theology, though it was by the study of breeding and acclimatization—one of the society's objects—that Darwin's thought was given its direction. The founders, however, hardly foresaw in their institution the present school of anatomy, cen-

ter for laboratory work and clearing house of zoological knowledge generally, with bearings on animal and human interests in all parts of the world. But such has the Zoo grown to be, and, in view of the shrinkage of space and the development of countries unopened a century ago, its importance can hardly be overestimated.

If its contributions to science are great, so also are its interests and responsibilities in other spheres. Its experience and ascertainments have a strong bearing on the conduct of men towards animals. The ethics of vivisection, of teaching animals to perform and of hunting and shooting them indiscriminately, and the provision against their ultimate extermination are all matters of concern to the society, and its opinion on them must carry great weight. Of all possibly none in certain countries is more important than the safeguarding of native fauna from the ruthless pressure of man. It is for this reason partly that photographs, such as those we are now publishing, have become for so many a welcome substitute for the traditional spoils of the hunter. In the last resort the question rests on the state of public opinion, which at home can hardly be fostered better than by a sight of the animals themselves—especially in such surroundings as approximate as nearly as confinement or restrictions will permit to natural conditions. And it is for this reason that the establishment of the Zoo's new park at Whipsnade is so happy an innovation. According to the able secretary of the Zoo, Dr. Chalmers Mitchell, it may be regarded as a link between the Zoo of an older fashion and those still larger reserves which statesmanship has already set apart as sacrosanct for native fauna in Africa, North America and elsewhere. The centenary of the Zoo and the prospect of the opening of the Whipsnade estate next year should give a new orientation to this practical branch of animal-keeping, and serve to enforce more strongly than ever upon a nation with immense zoological responsibilities the nature of its trust.—*The London Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN APPARATUS FOR THE STUDY OF MAT-FORMING FUNGI IN CULTURE SOLUTIONS

IN recent years considerable progress has been made in the physiological study of fungi, particularly as regards their organic nutrition. The technique usually employed in such work has been to grow the fungus in flasks containing a sterile liquid medium, and to deduce the results from the amount of growth of the fungus mats and analysis of the medium after growth. This, in principle, is the same as the methods used for the study of the inorganic nutrition of higher plants. For certain types of work with higher plants Johnston's[1] constant flow apparatus has proved of great help, and it was while trying to adopt the principle of this for the growing of mat-forming fungi that the apparatus to be described was tested out. While its use was primarily intended for the growing of fungi on liquid media under constant hydrogen-ion concentration, it can be seen that the method readily lends itself to studies regarding the inorganic and organic nutrition of micro-organisms.

There are many objections to be raised against methods now in use for the study of micro-organisms in culture solutions under constant pH. Sideris[2] enumerated some of them, but his own apparatus leaves much to be desired. By means of tubing he withdrew a sample of the medium in the flask in which the fungus was growing, titrated it to the original pH of that flask and then added acid or alkali to the remaining solution in proportion to its volume. Quite apart from the fact that it requires extreme care to adjust the pH in this manner, the important point seems to have been overlooked that the composition of the medium in the flask is being changed after each titration. While the apparatus may have been suitable for the particular work in hand, it does not lend itself to any work in which comparison of the results obtained is to be the basis of the conclusions drawn, for each flask would have contained a medium of different composition from the others.

Obviously the most desirable type of apparatus would be such that it would allow constant flow of a fresh medium of the same composition under the mats during the whole period of their growth. Since this is only practical in certain exceptional cases, the next best step would be to drain at intervals all the medium from the flask and refill from a reservoir. In this way the method adopted approaches as closely as is desired to the method of constant flow. This is the principle of the apparatus in the accompanying diagram.

The flask *A* is a reservoir containing the medium of desired composition and adjusted to any pH at which the fungus is to be grown. The glass tube *F* is connected at *C* to a Y tube, thus allowing two cultures to be grown on the same medium. Any number of these small flasks may be connected up in this manner, this being especially desirable when an average weight

[1] E. S. Johnston. "An Apparatus for Controlling the Flow of Nutrient Solutions in Plant Cultures," *Jour. of Plant Physiology*, 2: 213–15. August, 1927.

[2] C. P. Sideris. "An Apparatus for the Study of Micro-organisms in Culture Solutions under Constant Hydrogen Ion Concentrations," SCIENCE, July 4, 1924, vol. 60, No. 1540, pp. 17–19.

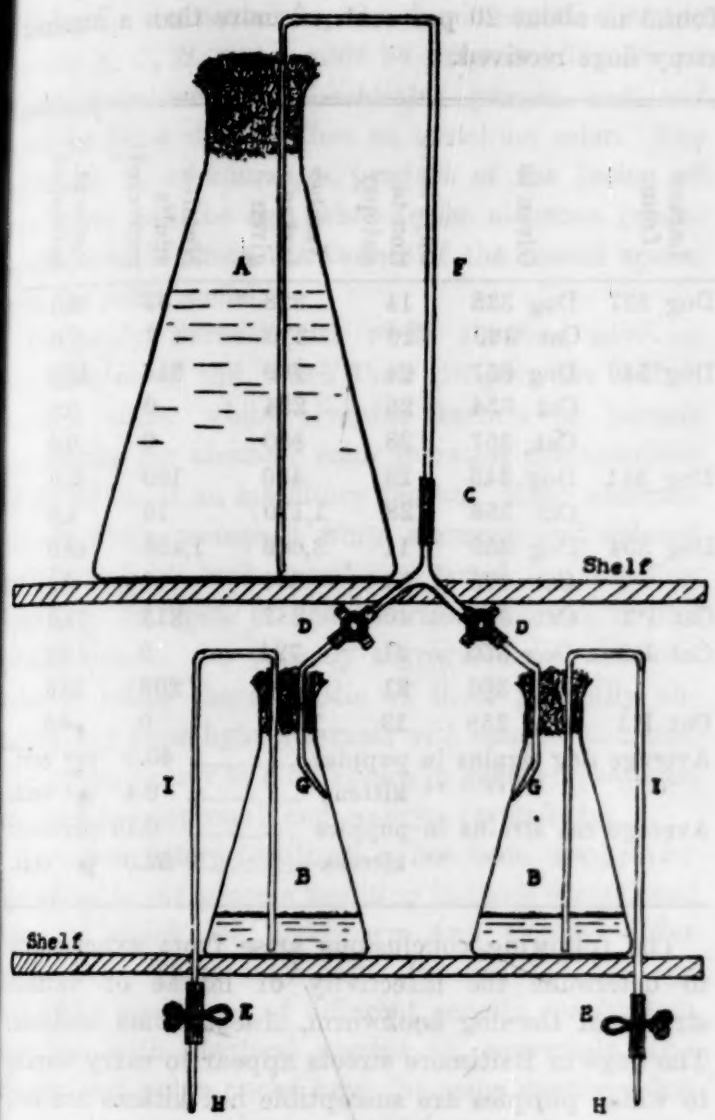

FIG. 1

of mat produced on a given medium is being determined. Flask *B* is supplied with the medium by glass tube *G*, the supply being regulated by screw-clamp *D*. The solution is withdrawn from *B* by means of tube *I* which is joined to the outlet tube *H* by a short piece of rubber tubing having a pinch clamp *E*.

The setting up of the apparatus may be done in several ways, but the following has proved the most desirable. Flask *A* is filled with the medium and tube *E* held in position with cotton-wool. The end of this tube, which is connected by means of a short piece of rubber tubing *C*, is plugged with wool and a paper cap fastened over it. This flask may then be sterilized in the autoclave. The other half of the apparatus is also connected up, the clamps being left loose, as otherwise the rubber tubing is liable to become sealed on the inside. The flasks *B* are left empty and the open ends of tubing plugged up, after which the whole is sterilized in an autoclave. After sterilization flask *A* is placed on an upper shelf with the other flasks below it. Tube *F* is connected at *C* and the clamps fastened in their respective positions.

A vacuum is now connected with one of the outlet tubes *H*, clamp *E* is opened, the fingers are placed firmly over the cotton of flask *B*, and the clamp *D* is carefully loosened. After a trial it becomes a simple matter to cause the syphon system from flask *A* to work. The clamps are closed when the solution in *B* reaches a desired level, the flasks having been graduated with file marks prior to being connected up. The other clamp *D* is now opened, and so both of the smaller flasks *B* are filled to the proper level. The glass tubes *F*, *G* and *I* are kept full of the solution, air bubbles being removed by tapping during the flow of the solution. Inoculation may now be made by carefully removing the plugs in flasks *B* and introducing the spores or mycelium with a needle.

The solution is withdrawn from *B* by opening clamp *E*, care being taken that when almost all has run out the syphon is not broken. The refilling is now made by opening clamp *D*. The solution should be run down the side of the flask from *G* to prevent the mat being submerged. The above directions are purposely given in full and are meant to serve merely as a guide, for the operation of this apparatus becomes simple after a little experience with it.

A convenient size for flask *A* is two liters, while each flask *B* may be 300 ml. capacity. For most determinations 100 ml. of the medium in each flask *B* has been found to be a suitable volume and is sufficient not to allow it to become exhausted of nutrients in a short period. When the set-up apparatus is not autoclaved prior to its use, the tubes may be sterilized with 80 per cent. alcohol, following by flaming. This method of sterilization has proved very satisfactory. The whole apparatus may be modified according to the wishes of the individual worker, but the principle of an entirely fresh solution being supplied should be retained.

The uses to which this apparatus can be put are not in the least confined to hydrogen-ion control. The solution in flask *B* may be withdrawn as often as desired and determinations made upon it. From experiments already run it seems that an examination of the rate of oxalic acid excretion at different pH values and different sugar concentrations of the original medium would prove to be an interesting study. In addition, a large number of other problems which may be carried out with mat-forming fungi by means of such an apparatus suggest themselves, namely, the secretion of enzymes by the growing organism, the toxic effect and the absorption of certain substances at different stages of growth, and the ability of a well-established fungus mat to increase further in weight on different media supplied from separate reservoirs.

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SPECIAL ARTICLES

STRAINS OF THE DOG HOOKWORM, ANCYLOSTOMA CANINUM, SPECIFIC TO THE DOG AND TO THE CAT

IN another paper[1] experiments are described which demonstrated two strains of the dog hookworm morphologically identical but differing in their host specificity. One, originally recovered from a Baltimore dog, was highly specific to that species of host in that an average of 50 per cent. of the larvae matured in puppies while less than 1 per cent. matured in kittens. On the other hand a strain from a cat from Long Island was specific to the cat in that an average of 45 per cent. developed in kittens while less than 5 per cent. matured in puppies. On the basis of these findings and certain facts of distribution it was suggested that in a locality where this hookworm is common in cats a special strain specific to cats probably existed. It is now possible to present more definite evidence to substantiate this postulate.

A number of stray dogs from the streets of Baltimore which have come into the laboratory harbored the dog hookworm, *Ancylostoma caninum* Erc. 1859. Cultures were made from the stools of these dogs by stirring them into granulated charcoal, and the freshly isolated larvae used for infection experiments. The larvae were administered by mouth in double gelatin capsules following the technique described previously.[2] With the aid of Dr. N. R. Stoll similar cultures were obtained from the feces of cats in the vicinity of Princeton, N. J. Larvae from these were used for similar experiments as shown in the accompanying table.

All of the experimental animals used were young enough to be highly susceptible to the standard strains mentioned above. The average condition as shown in the table comes surprisingly close to the values for the standard strains when the length of the series and the variation is considered. It is evident that the strains harbored by these dogs in Baltimore are adapted to the dog and not to the cat. On the other hand the strains received from Princeton cats seem to be adapted to cats but not to dogs. Dr. Stoll has found eight of thirteen cats examined to be infected with these hookworms. As mentioned in a previous paper (*loc. cit.*) cats in Baltimore have never been found to harbor this species, but it was found in about 20 per cent. of more than a hundred stray dogs received.

Larvae from	Given to	Days infection to autopsy	Number larvae given	Number adults recovered	Per cent. developed
Dog 337	Dog 338	14	228	53	23.0
	Cat 349	20	316	3	1.0
Dog 340	Dog 357	24	700	314	45.0
	Cat 354	25	234	0	0.0
	Cat 357	28	880	0	0.0
Dog 341	Dog 345	23	460	199	43.0
	Cat 356	28	1,170	16	1.0
Dog 354	Dog 355	11	3,000	1,458	49.0
	Cat 375	14	600	0	0.0
Cat P1	Cat 323	40	287	215	75.0
Cat P2	Dog 350	21	724	2	0.3
	Cat 360	21	703	208	30.0
Cat P3	Dog 358	13	1,200	0	0.0
Average dog strains in puppies				40.0	per cent.
" " " " kittens				0.4	per cent.
Average cat strains in puppies				0.15	per cent.
" " " " kittens				52.0	per cent.

The following conclusions arise from experiments to determine the infectivity of larvae of various strains of the dog hookworm, *Ancylostoma caninum*. The dogs in Baltimore streets appear to carry strains to which puppies are susceptible but kittens are not, as indicated by infection experiments. Cats from the vicinity of Princeton, N. J., appear to carry strains to which kittens are susceptible but puppies are not.

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HETERO-FERTILIZATION IN MAIZE

THERE is abundant evidence that the endosperm and the embryo of the maize kernel regularly are genetically identical. Were they not, there would be no reason for selecting on the basis of endosperm characters among the individual kernels in genetic or breeding experiments. In connection with the writer's investigations on the inheritance of scutellum color, however, considerable data have been obtained which show that this usual condition is not universal.[1]

"Colored Scutellum" already has been described as a heritable character of maize (Sprague).[2] The development of scutellum color is dependent upon several factors, the interaction of which will be described later. Before purple or red color can

[1] J. A. Scott, 1929, "Experimental Demonstration of a Strain of the Dog Hookworm, *Ancylostoma caninum*, Especially Adapted to the Cat," *Jour. Par.*, in press.

[2] J. A. Scott, 1928, "An Experimental Study of the Development of *Ancylostoma caninum* in Normal and Abnormal Hosts," *Amer. Jour. Hyg.*, 8: 158.

[1] These investigations were conducted in the department of plant breeding, Cornell University, and at the North Platte Substation, North Platte, Neb.

[2] G. F. Sprague, *Jour. of Heredity*, 18: 41–44, 1927.

develop in the scutellum, the fundamental aleurone factors *A*, *C*, *R*, and *i* must be present. The *Pr pr* factor pair which differentiates purple and red aleurone has a similar effect on scutellum color. The scutellum is, of course, a product of the fusion of one sperm and the egg, whereas the aleurone (endosperm) results from the fusion of the second sperm with the polar nuclei.

Ordinarily, kernels with white aleurone have no scutellum color and, when their progeny are selfed, produce either white aleurone kernels or kernels segregating for aleurone color in ratios characteristic of the action of an inhibitory factor. Many aberrant kernels which possessed white aleurone and colored scutellums have been found and tested for breeding behavior. In spite of the colorless aleurone of the parent kernels, the progeny segregated for aleurone color in ratios characteristic of those generally obtained only from hybrid kernels with colored aleurone. This points clearly to a difference in genotype between endosperm (aleurone) and embryo (scutellum).

The term hetero-fertilization has been applied by the writer to the process resulting in those exceptional cases in which the endosperm and embryo differ genetically. These may occur because (a) the egg and polar nuclei are of different genetic constitution and fuse with identical sperms or, conversely, (b) the egg and polar nuclei have the same genotype but fuse with sperms having unlike genotypes during syngamy. Either of these phenomena would give rise to hetero-fertilized kernels.

It is obvious that hetero-fertilized kernels may be produced and escape detection because of phenotypical identity with their normal sibs. Hetero-fertilized kernels of this kind undoubtedly occur unnoticed in much maize material. For the ready identification of hetero-fertilized kernels, the embryo and endosperm must be of different phenotypes. The relation of aleurone and scutellum factors provides an ideal combination for detecting hetero-fertilization. The ease of identifying a particular kind of hetero-fertilized kernel, namely, those having a colorless aleurone and colored scutellum, has been taken advantage of in studying this phenomenon genetically. There is some evidence that hetero-fertilization may occur only in the presence of a certain gene or complex of genes. Some strains show no hetero-fertilization among several thousand kernels, whereas other strains show as many as 10 per cent. of hetero-fertilized kernels, and individual ears have shown much higher percentages of this anomaly.

It is conceivable that hetero-fertilization may be brought about in various ways. Dispermy, non-disjunction of one or more chromosome pairs when the generative nucleus divides to form the sperms, the persistence and functioning of the four megaspores, or mutation of one of the aleurone or scutellum factors might result in hetero-fertilized kernels. The genetic tests applied have failed so far to distinguish with certainty between the possible causes of hetero-fertilization. The occurrence of the phenomenon, however, is abundantly proved.

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Production of X-rays according to wave mechanics: A. SOMMERFELD (by invitation). Twenty years ago the author published a paper on the production of X-rays, especially on the angular distribution of X-rays, produced by high speed cathode rays. This work was done entirely on the basis of classical electrodynamics. New experiments taken with very thin anti-cathode by Kulenkampff and D. L. Webster make it desirable to treat the same question from the standpoint of wave mechanics. The general radiation emitted by the cathode particles in the process of stopping is computed from the matrix element of the coordinates. The initial and final state of cathode particles are treated as plane electronic waves. The forward shift of the maximum of the emitted intensity is calculated from a factor depending on the arithmetical mean of the initial and final velocity of the electron. The use of parabolic coordinates is proved to be convenient for expressing the distribution of the incident as well as the emergent electronic wave.

New studies of X-ray spectra from ruled gratings: J. A. BEARDEN and C. E. HOWE (introduced by Arthur H. Compton). One of us (J. A. B.) has been making precision measurements of the X-ray spectrum lines from copper (K series), trying to establish a more reliable standard of X-ray wave-lengths than that resulting from crystal measurements. A glass grating of 600 lines per millimeter and a glass and a speculum metal grating, each with 50 lines per millimeter, were kindly ruled for this work by Professor Michelson. Every one of the thirty-one plates obtained from these three gratings gave wave-lengths greater than those calculated from crystal diffraction data. The weighted mean value of the wave-length for the Kα line of copper is $1.5439 \pm .0002$ A, and for the Kβ line, $1.3940 \pm .0002$ A. These values are .35 per cent. higher than the wave-lengths of these lines given by Siegbahn from crystal measurements. Using these wave-lengths, the grating space of calcite is calculated to be 3.039 A, Avogadro's number as 5.999×10^{23} per gram molecule, and the electronic charge as $e = 4.825 \pm .005 \times 10^{-10}$ e.s.u. The last result differs so greatly from the usually accepted value, $4.774 \pm .005 \times 10^{-10}$ e.s.u. as to suggest a hidden error. The other one of us (C. E. H.) has been studying the spectra of very soft X-rays, especially the L series, whose wave-lengths lie between 10 and

40 A. Some of these spectra have been investigated by Thoraeus using crystal methods. His results agree well with the present ones, except that our wave-lengths are uniformly about 0.6 per cent. greater than those of Thoraeus. This is perhaps a difference of the same kind as that which J. A. B. finds with the Kα line of copper. The Lα line appears to be present for all the elements within this range. The Lα line seems to appear for elements of atomic number as low as 22, whereas Foote's extension of Stoner's table would predict its absence for atomic numbers lower than 24.

Two-electron jumps in X-ray spectra: F. K. RICHTMYER (introduced by Ernest Merritt). The several theories which have been previously proposed to explain the origin of X-ray satellites ("non-diagram" lines) involve a single-electron jump between two ionized states. An alternative theory, which in many respects agrees better with the experimental facts, is that satellites are produced by the simultaneous jumping of two electrons into the vacant orbits of a doubly ionized atom, both jumps cooperating to emit a *single* quantum. In support of this theory are the following facts: (1) K-satellites seem to occur only for those elements, Na to Zn, for which the third (or M) "shell" is increasing from one (for Na) to 18 (for Zn) electrons. Similarly, L-satellites occur only for the elements from Cu to Sn, over which range the fourth (or N) shell is increasing from one to eighteen electrons. This suggests that the second electron-jump is into a vacant place in an outer, incomplete shell. (2) Many of the plates show a continuous spectrum extending for some distance (toward short wave-length) from the satellite structure. This might be due to electrons, coming from outside the atom and possessing kinetic energy, jumping into the vacant orbit in the outside shell. (3) A Mosely graph is obtained when the square root of the frequence difference between a satellite and the parent line is plotted as a function of atomic number. This frequency difference is proportional to the energy which the second (*i.e.*, outer) electron jump adds to that corresponding to the parent line to give the satellite. Over the range of atomic numbers for which class of satellites are found, one would therefore expect a Mosely graph from the above plot.

Hyper-fine structure in spectral lines—especially those of singly ionized praseodymium: R. C. GIBBS and H. E. WHITE. Dr. King, of the Mount Wilson Laboratory, has recently published his temperature classification of the lines of praseodymium obtained from both the furnace and the arc and has indicated which of these lines probably arise from the singly ionized state. He has also noted the number of components into which some of these lines appear to be split up. These components for complex lines range in number from two to six with many in doubt because of the lack of sufficient dispersion to separate the components distinctly. Last summer photographs of the emission lines from a carbon arc cored with praseodymium oxalate, most of the strong lines of which according to King's classification are those from singly ionized atoms, were made over the region 3,900 to 5,000 Angstroms using the fourth order spectrum of the 75-foot solar spectrograph on Mount Wilson. A dispersion of nearly an Angstrom per centimeter was obtained and the complex structures of many lines were clearly resolved. Within the region studied all the completely resolved fine structures consist of six components. The frequency intervals between the components of any one line follow very closely the Landé interval rule, and the relative intensities of the components decrease with the interval. The components of some lines show decreasing intervals and intensities toward longer wave-lengths while others are similarly degraded toward shorter wave-lengths. Practically all the lines thus resolved are listed by King as belonging to the spectrum of the singly ionized atom. A study of the Zeeman patterns of some of these complex structures will doubtless help to classify these complex lines and possibly to identify the change in atomic configuration that is responsible for this unusual uniformity in the number of fine structure components. It will also be interesting to determine whether other elements, especially those among the rare earths, possess a similar complexity of structure.

Some new features of the band spectrum of oxygen, and the relative abundance of the isotopes O^{16}, O^{18}: HAROLD D. BABCOCK (introduced by C. E. St. John). Data derived from a band spectrum are here applied to the problem of the structure of molecules, somewhat analogously to the explanation of atomic features by the data of line spectra. Each absorption band produced by the symmetrical molecule of atmospheric oxygen shows a sequence of pairs of lines corresponding to successive increments of one unit to the rotational energy of the molecule. The absorption produced by about 30 kilometers of air, when examined by a powerful spectrograph, shows the presence of extremely faint doublets falling half way between the strong ones. These "missing doublets," now shown to exist with an intensity of the order of one ten thousandth of the strong ones, indicate a slight dissymmetry in the oxygen molecule hitherto unknown. In a description of the oxygen bands given two years ago accurate values were found for certain constants of the molecule, and a faint band was analyzed for the first time. Recently Giauque and Johnston have shown that this new band is due to a molecule in which one of the ordinary atoms of oxygen is replaced by an atom chemically the same but of mass 18 instead of 16, *i.e.*, an isotope. Further measurements are now presented in support of their conclusion, and still another faint band is discovered, but it does not appear to be due to the isotopic molecule. From measurements of the relative intensity of the bands due to ordinary oxygen and to the isotopic molecule it is found that in our atmosphere there are 1,250 ordinary oxygen atoms of mass 16 for every one of mass 18.

On the use of the electrodeless ring discharge to excite extreme ultra-violet spectra: K. T. COMPTON and J. C. BOYCE. A quartz tube sealed to the front of a vacuum

spectrograph and wound externally with twelve turns of heavy wire served as the discharge vessel. Purified gas was slowly admitted to this tube through an adjustable capillary leak, pumped out of the spectrograph by fast pumps, and returned to the purifying system, thus giving a continuous circulation of purified gas. The gas in the tube was electrically excited by high frequency currents through the surrounding coil, produced by either of two outfits, one giving up to 3.5 K. W. at 300,000 cycles and the other up to 0.75 K. W. at 800,000 cycles. Gas pressures between 0.001 and 0.15 mm were used. With large power and low gas pressure extremely high stages of ionization were attained. For example, in argon the strongest lines in the spectrum belong to A III and A IV. A V is found. A II is quite strong but A I is very weak. Similar results obtain with the other gases used, *viz.*, neon, nitrogen and oxygen. Other experiments suggest nearly 100 per cent. ionization of the gas, so that these high states of ionization may be due to ionization in successive stages. However, the voltages induced may suffice to produce this multiple ionization by single electron impacts, since the voltage at the terminals of the coil may reach values as high as 30,000 volts. Direct tests, necessarily conducted at much lower voltages, failed to show more than double ionization by single impacts. An interesting feature of this type of discharge is the extent to which gas, probably in the form of ions, is driven so firmly into the walls of the tube that ordinary heating will not dislodge much of it. For this reason we use a quartz tube to permit intense heating in order to purge the apparatus of one gas before admitting another. Otherwise each photographic exposure shows spectrum lines of all the gases which have previously been in the apparatus. We have analyzed the main spectral structure of Ne III in the region 200 to 1,300 A, and have made some progress with Ne IV, A III, A IV and A V. The ionization potential of Ne III is 63.2 volts and that of A III is 40.7 volts. Study of relative intensities with varied power input aids in the classification of the lines.

On the arc spectrum of nickel: HENRY NORRIS RUSSELL.

The absolute value of the international ohm: HARVEY L. CURTIS, CHARLES MOON and C. MATILDA SPARKS (introduced by George K. Burgess).

Scattered light (illustrated): R. W. WOOD.

Hot springs of Yellowstone Park: ARTHUR L. DAY.

Reconciliation of binocular and monocular fusion: CHRISTINE LADD-FRANKLIN. Binocular fusion of colored lights (red plus green into yellow—yellow plus blue into white) certainly takes place in some nervous center higher than the retina. Does it follow from this that the same event when the lights are thrown together upon *one* eye (monocular fusion) also can not take place in the retina? This has been maintained by G. E. Müller (*Z. f. Psychol.* Vols. 10 and 14) and quite lately by Hecht (*Proc.* Nat. Acad. Sciences, 1928), and the latter maintains that this works against the Hering theory and also against the development theory which I have defended. But Hering has always affirmed that *he does not state* where he supposes his antagonistic processes to take place, and his present chief defenders (Tschermak and Müller) assume that it takes place in nerve fibers, or in nerve centers. I have been less prudent myself, but the processes that I assume may also take place higher up (as Troland has shown). But the situation is not so simple as it seems. There must be *some* marked difference between the two events, for fusion is only one of *four* different events that may take place when the two eyes are stimulated severally: We may have: (1) dominance of one eye over the other; (2) rivalry; (3) transparence of one color through the other; or (4) fusion—and the latter only under very special conditions (Kuroda). If we take good, well-saturated, spectral colors (Trendelenburg), the field must be very small (only ½ to 1 degree in diameter); with very unsaturated colors (such as Hecht makes use of) it is easy to get. We have to explain, therefore, why *binocular* fusion is so hard to obtain. It may be that the physiological process in question may take place at more than one level (after-images must take place in the very highest centers, but surely not only there). But it may also be that reflex currents (Frank Allen, Kappers) secure a necessary participation of retinal processes even in the case of binocular fusion. The case against retinal processes is thus not so strong as it might seem to be at the first glance.

Further remarks concerning thermionic "A" and "b": EDWIN H. HALL. For metals in which the photoelectric work function, represented by b_o, is independent of temperature the expanded form of the thermionic emission equation should be $I = Fe \cdot \varepsilon^{az} T^q \cdot T^{0.5}\, \varepsilon^{-bo/T}$ (1), where Fe is a universal constant, while a, z and q are constants, or near constants. If A' is put for $Fe \cdot \varepsilon^{az}$, this equation becomes $I = A' T^q \cdot T^{0.5} \varepsilon^{-bo/T}$ (2). It is shown that $A'\ T^q$ is the same for all metals. If we choose to give A such a value that $AT^{1.5} = A' T^q$ (3), then A, though its physical meaning will be less definite than that of A', will be the same for all metals. Thus we get from (2) and (3) the familiar Richardson equation, $I = AT^2 \varepsilon^{-bo/T}$ (4), with A a "universal constant." If the photoelectric work function is not a constant but is properly represented by $(b_o - \gamma T)$, where b_o and γ are constants, the emission equation becomes, from (2), $I = \varepsilon^{\gamma} \cdot A' T^q \cdot T^{0.5} \varepsilon^{-bo/T}$ (5), or from (4), $I = \varepsilon^{\gamma} \cdot AT^2 \varepsilon^{-bo/T}$ (6). Then A remains a universal constant, but $\varepsilon^{\gamma} A$ is not such a constant. The factor ε^{γ} corresponds to the factor ε^{a} used by Du Bridge in a recent paper. The factor ε^{az} of equation (1) is taken by Du Bridge to be 1, a being treated as zero.

Biharmonic functions and generalizations: EDWARD KASNER. The author showed that if a function $F(xy\ x_1\ y_1)$ is converted by every *conformal* substitution $x_1 = \alpha(xy)$, $y_1 = \beta(xy)$ into a *harmonic* function $K(xy)$, then F must be *biharmonic* in the sense of Poincaré, that is, the real part of an analytic function $f(z_1 z_1)$ of two complex variables. This is also true if we merely use the similitude group. It is not true if we use, for example,

the translation group or certain sets of symmetries and so larger classes of functions F are obtained. The most interesting generalization is for the group of rigid motions. The transformations associated with an arbitrary function $F(xy\,x_1\,y_1)$ do not usually constitute a group, and examples of this kind are also studied. Extensions to any number of variables are obtained.

Potential energy functions of diatomic molecules: PHILIP M. MORSE and E. C. G. STUECKELBERG (introduced by K. T. Compton). The problem of the determination of the potential energy of a diatomic molecule as a function of the nuclear separation is of importance in several fields of physics and chemistry, for from this energy can be obtained the valence forces and heats of dissociation of the molecules and their spectroscopic behavior. This problem has been attacked from two different approaches: (1) The potential energy for the simplest molecule, the hydrogen molecular ion, has been calculated by means of the wave mechanics for the first ten states of electronic excitation. This provides a basis from which approximate formulas might be obtained, *ab initio,* for the potential energies of the molecules. (2) A formula has been derived by wave mechanical means whereby a close approximation to the potential energy function of any diatomic molecule can be obtained by analysis of the band structure of the molecular vibration spectrum. By means of a discovered empirical rule, $r^3_0\omega_0 = K$, the normal nuclear separation r_0 can be obtained without analysis of the rotation bands. This method provides a basis whereby approximate formulas can be obtained empirically for the potential energy functions of molecules. The two methods check satisfactorily in the cases where curves by both methods have been calculated. Curves calculated by the second method have been successfully applied in the explanation of the critical potential and band intensities of the oxygen molecule.

Alternating-current three-terminal electrically conducting nets: A. E. KENNELLY. It is known that an electrically conducting network or net, carrying steadily sustained alternating currents from a pair of input terminals AG, to a pair of output terminals BH, offers a certain hyperbolic angle which is, in general, complex or has a real component associated with a real hyperbolic angle and an imaginary component associated with a real circular angle. When the terminals G and H are united on the net, the system becomes a three-terminal net. There are evidently three ways in which the A, B and GH leads can be applied to the net in rotation, and these may be called the three aspects of the net with respect to the three terminals. It is known that when the net carries steady continuous currents, the three real hyperbolic angles of the net θ_{AB}, θ_{AG}, θ_{BG}, in the three aspects, have corresponding gudermannian circular angles β_{AB}, β_{AG}, β_{BG}, which sum up to just π radians or 180°, and so may be regarded as defining a family of plane triangles. It has recently been ascertained, however, that the proposition extends to alternating-current nets, for which both the hyperbolic angles θ_{AB}, θ_{AG}, θ_{BG}, and their respective gudermannians β_{AB}, β_{AG}, β_{BG} are complex. In such an alternating-current case, the three real components of the β's add up to 180°, and the three imaginary components of the β's cancel, or add up to zero. The original continuous-current proposition thus extends to alternating-current nets.

The monophone—a one-way telephone for program service: GEORGE O. SQUIER. What we now call broadcasting by space-radio has already reached the "saturation point" in its assigned band of frequencies. The new fields for the use of this young art which now appear regularly clearly show that there is little chance of overtaking them with adequate channels for years to come. The monophone, therefore, proposes to put the telephone wires now leading into millions of homes to work sixteen hours a day in providing multiple program service. It must and does accomplish this without interfering with the regular point to point telephone service or changing its present equipment in any way. To indicate the electrical efficiency of this form of wired-radio, as compared with present space-radio, it may be stated that fifty watts of energy has been found adequate to saturate satisfactorily approximately 500 cable-pairs. A small and compact 5-watt transmitting unit for Army Signal Corps use and for demonstration purposes throughout the country has been constructed. These units are capable of supplying about 200 receiving sets. The best minds from our state universities and colleges and the departments at Washington must be added to the teaching staff of our high schools through the development and perfection of chain broadcasting as a national educational function. This will result in elimination of waste in the present duplication of teaching staff, and reduce rather than increase the annual educational budget by dispensing with the inefficient teacher and raising the standard of the smaller staff then required. The needs for new channels of communication require that ultimately both the telephone wires and the power wires into the home should be utilized in competition or cooperation. The super-university of the United States, for both youth and adults, can become in the era ahead the greatest educational and cultural institution in all history. Radio is the new agency by which alone this is possible.

A new microphone: ARTHUR L. FOLEY (introduced by Dayton C. Miller). The author has devised a microphone which is essentially a multiple fixed-plate air condenser. The action of the condenser depends upon the fact that the compressions and rarefactions of the sound waves passing between the condenser plates change the dielectric value of the air between the plates and therefore the capacity of the condenser itself. The variations in the density of the air may be increased, and therefore the sensitivity of the microphone will be increased, by placing an ebonite (or other non-conducting) plate in contact with the rear surface of the condenser so as to reflect the waves back between the condenser plates. Being free from diaphragms or other movable mechanical parts, the new microphone is wholly independent of frequency.